TEST OF INTERNATIONAL HARVESTER CO. GASOLINE ENGINE

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INSTALLATION AND TEST OF AN INTERNATIONAL HARVESTER CO. GASOLINE ENGINE

A THESIS

PRESENTED BY

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AND
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MECHANICAL ENGINEERING

1911

G. F. Gebhardt
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L. C. Monin

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INTRODUCTION

It has long been a matter of contention as to what is the effect, on the various efficiencies of an internal combustion engine, of heating the jacket water, or the inlet air, and also of injecting water into the cylinders.

For this reason we proposed to make a sufficient number of runs on the above basis to determine this conclusively and also to make a number of brake horse power runs under normal conditions, with which we could compare our other results.

For conducting these tests we used an International Harvester Company Victor, Two Cylinder, Four Cycle, stationary gasoline engine, rated at 25 horse power. This engine was one which was loaned to the Armour Institute of Technology by the International Harvester Company for testing purposes and as it had not yet been installed at the time we pro-

posed to begin our tests, we included the installing and design and installation of a complete testing apparatus in our thesis.

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The results of the test and the conclusions drawn comprise the main portion of the following pages. The tests were made in the following order.

1) Tests for efficiency at different brake loads from zero to a maximum horse power; other conditions normal.

2) Tests for efficiency at varying outlet jacket water temperatures, inlet water temperature being constant, and let in at the bottom of cylinder so that the cylinder wall temperature is constant and only combustion chamber affected. Other conditions normal.

3) Test for efficiency at various temperatures of the intake air to the carburettor; other conditions normal.

4) Test of the effect of injecting water into the cylinders, at various brake loads.

A number of auxiliary tests were also made to determine the B. T. U. per pound of the gasoline used. In making the determination we used a Mahler bomb calorimeter, the gasoline being

absorbed by napthalene.

DESCRIPTION OF THE ENGINE

The engine which was tested is known as the International Harvester Company Victor, two cylinder, vertical engine, having an eight inch bore and a ten inch stroke, and is rated at 25 horse power at 325 R. P. M. by the builders. It is a four cycle engine and is especially designed for purposes where close regulation of speed is essential, and as the variation of speed from no load to full load is less than 4%, the engine can be direct-connected to generators. On this engine absolute interchangeability of parts has been the guiding principle, and there are no "rights and lefts" in its construction. Thus any piece used for any given purpose on one cylinder may be used equally well on the other, and the positions of the cylinders themselves may be transposed at will.

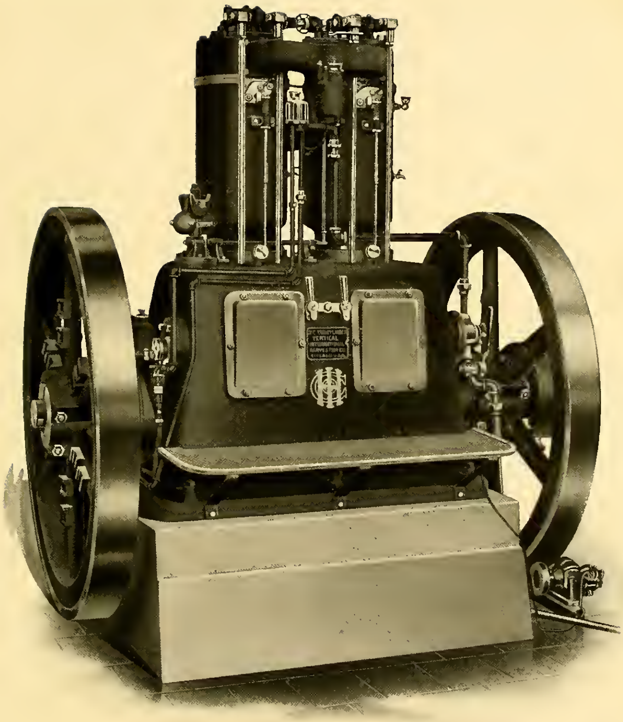

Figure 1. Front view two-cylinder, 25-horse power engine equipped with gasoline mixer

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FUEL. The engine can be equipped for the use of either city, natural or producer gas, or gasoline, as fuel, it being only necessary to change the pistons and the mixing valves according to the fuel to be used. In our tests we used gasoline which produces considerable power in excess of the engine's rating.

BASE. The engine base is cast in one piece, and then is accurately machined to receive the bearings. Four large openings in the crank case give access to the internalparts, these openings being covered by plates when the engine is in operation. There are ribbed projections on the base so that dripping oil from the top will run onto the main bearings and cam shaft. The vent valves, for relieving the compression in the crank case, are located at either end of the base and are outside of the path of the oil splash.

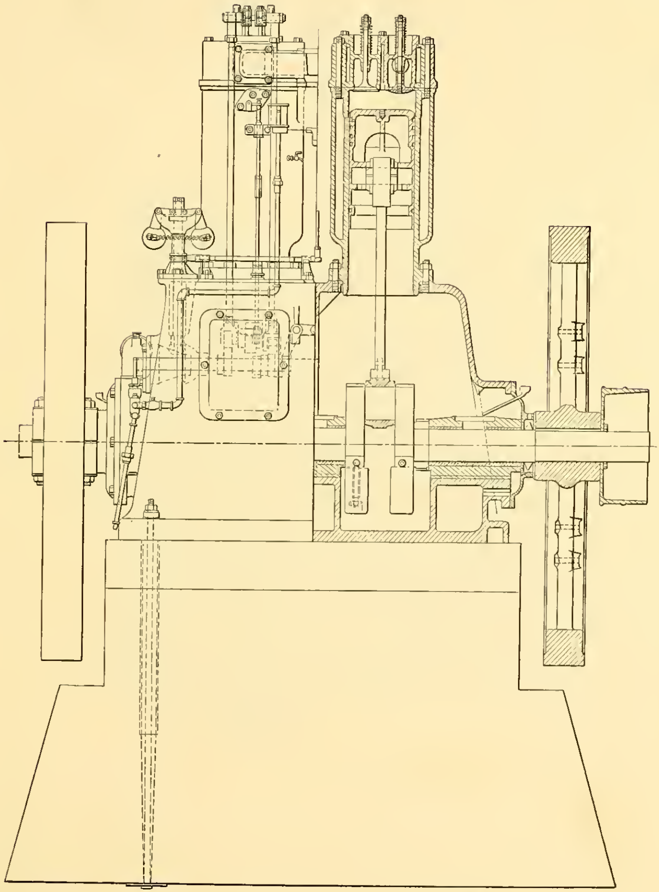

Figure 3. Sectional view of I. H. C. two-cylinder engine

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CYLINDERS. The cylinders are cast separately with removable heads. The heads are cored out to provide inlet and exhaust passages which open into the valve cages. The water jackets are cast integral with the cylinders.

CONNECTING RODS. The connecting rods are forged steel of the marine type at the crank end, and a solid end wedge take-up, at the piston end. At the crank end, the bolts are such that the upper half of the crank pin bearings are held firmly to the connecting rod regardless of the wear on its bearings, which are of phosphor bronze.

The upper or wrist pin box of the connecting rod is slotted out of the solid forging and has brasses with wedge adjustment. The top of the rod carries an oil pan, draining to the pin, and the lower end of the rod contains oil pockets on each side

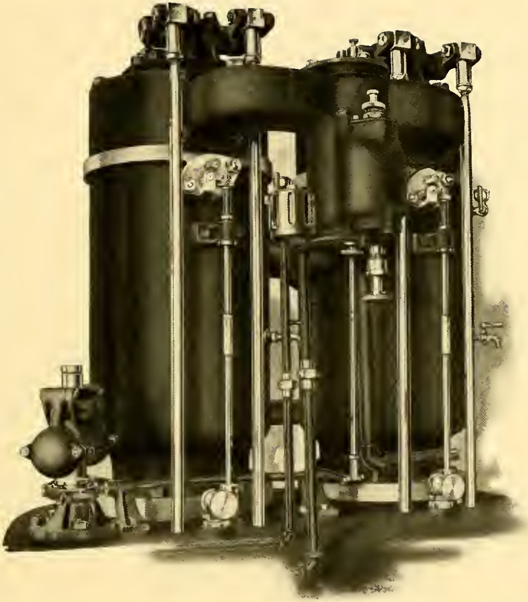

Figure 2. Cylinders and all connections

which collect the oil and carry it to the crank pin.

PISTONS. The pistons have four packing rings and a beveled oil-wiper ring, which is designed as a section of a cone so that on the down stroke of the piston it scrapes the oil off of the cylinder and thus avoids the pumping effect. For this reason a high oil level may be maintained in the base without danger of fouling the igniter or valves in the combustion chamber.

CRANK SHAFT. The crank shaft is four inches in diameter, of open hearth steel, and has a tensile strength of 75,000 pounds. It is supported by three bearings which are cast in the base and babitted. These are lubricated by the dripping oil from the top of the base and rest on flat surfaces, so that they may be easily leveled, after wear takes place, by placing thin metal liners under the box.

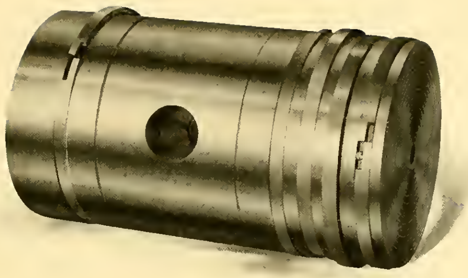

Figure 5. Piston

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CAM SHAFT. The cam shaft is of $1\frac{1}{4}$ inch steel and runs in bronze bearings. All gears and cams are held in place by tapered keys and set screws. The cam shaft is located just above the hand holes on the carburettor side of the engine and is easily accessible from the outside. Besides operating the cams it operates the governor, the gasoline pump and the air starting valve.

VALVES. Each valve is mounted in a separate cage placed in the cylinder head, which is very convenient in that a valve can be removed for regrinding by loosening only two bolts, without disturbing the cylinder head or breaking the water joint. The valves are of the poppet type and are both mechanically operated from the cam shaft by push rods and rocker arms. The valves are of a large diameter in proportion to the cylinder bore. The inlet valves are of one piece steel, but the exhaust valves are of cast iron with steel stems.

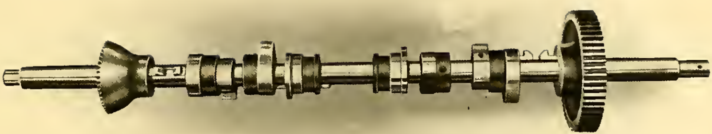

Figure 6. Cam shaft

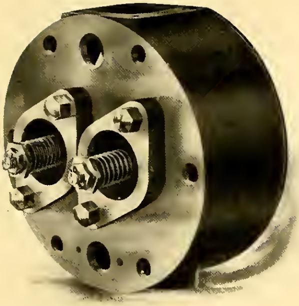

Figure 10. Top of cylinder head

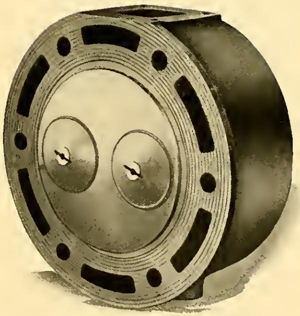

Figure 11. Bottom of cylinder head

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GOVERNOR:- The governor is of the fly-ball type and is spring driven from the cam shaft, the spring preventing the governor valve from being affected by sudden changes of speed due to shock or jar. This governor is very sensitive and operates the throttle valve which controls the amount and quality of fuel admitted into the cylinder. This method as used insures a power stroke for every revolution of the engine.

IGNITION. The ignition system is of the make and break type and runs either on batteries or auto-sparker. The movable electrode is provided with an outer bearing to support the end of the spindle which reduces compression leakage. The lower end of the igniter push rod bears upon a steel finger which rides on the ignition cam. The cam is formed like a spiral with a sudden drop at the end of the revolution. The finger may be moved horizontally across the cam by turning the igniter control knobs, on the

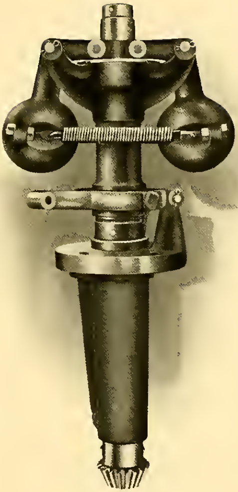

Figure 12. Fly-ball governor

crank case. When the knobs are turned down so that the connecting bar is in the lowest position, the igniters are in the "late" or starting position. When the knobs are turned up the connecting bar pulls the finger in against the direction of rotation of the cam shaft and causes the igniter to drop earlier in the cycle. The igniter knobs can be adjusted up or down by means of a threaded sleeve and lock nut. This makes an easy way of adjusting the time of ignition.

The current for the ignition is supplied by a Motsinger Auto-sparker which is mounted on a specially designed shelf directly over the fly wheel. The auto-sparker pulley, which is faced with leather, is run by friction on the fly wheel. This sparker, which is simply a small shunt wound dynamo, generates a current which is led through an intensifying coil and thence to the igniter terminals. Between the intensifier and the igniter a switch was placed

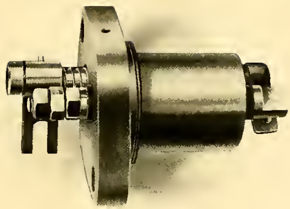

Figure 13. Ignitor

for starting duty on storage batteries. The auto-sparker is provided with a fly@ball governor on the back of the shaft, which lifts the sparker wheel off of the fly wheel by means of a link motion when the speed of the generator becomes excessive. The speed at which this occurs can be varied by means of an adjustable spring on the governor link mechanism. For our purposes the best speed was found to be about twelve hundred R. P. M.

CARBURETTOR. The gasoline mixing attachment which is shown in section and also complete in the accompanying cuts, operates as follows: The gasoline is pumped up from the gasoline tank by a pump operated from an eccentric set on one end of the cam shaft, to an overflow chamber where the level of gasoline in the carburettot is maintained constant by an overflow pipe leading back to the gasoline tank. From the overflow chamber the gasoline is sucked into the mixing chamber through a cone-nozzle which reduces it to a fine spray. Air is admitted through a balanced

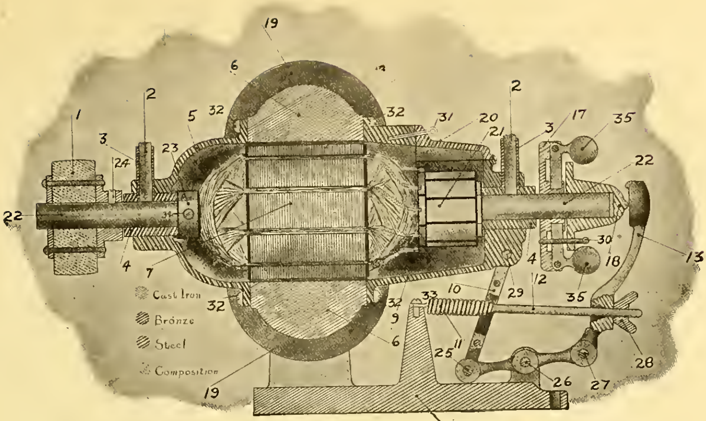

Fig. 2

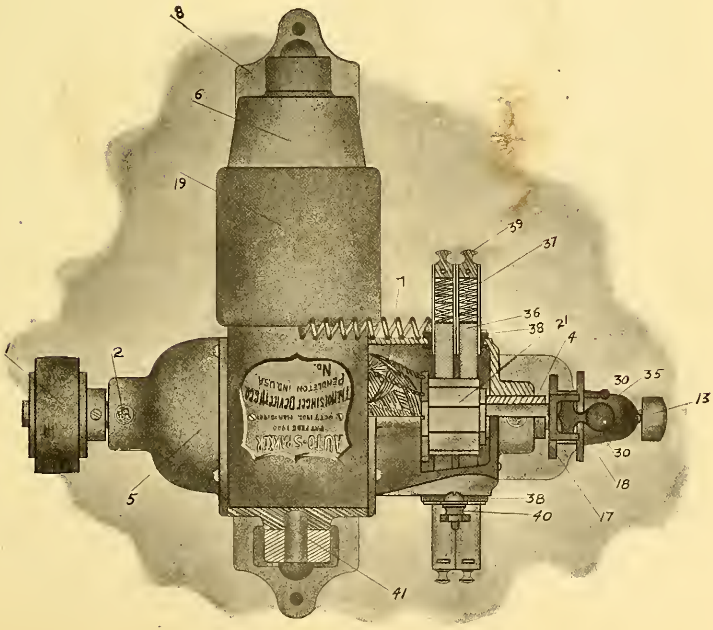

Fig. 3

throttle valve operated by the suction of the engine, which is drawn back to place by a spring after each suction stroke. On light loads, and on starting, all the air passes through a small opening in an anxiliary air valve which is arranged in such a manner that it does not open until the suction of the engine increases with the greater load.

Thus all the air comes in contact with the gasoline vapor and produces a rich mixture, insuring regular explosions and easy starting. With the heavier loads the valve is opened by the engine suction, allowing a greater volume of air to pass around the valve and thus diluting the mixture.

After passing the mixing chamber the mixture goes through the governor valves, which are opened by the governor rod in proportion to the speed of the engine and then it passes into the inlet manifold and distributed to the cylinders.

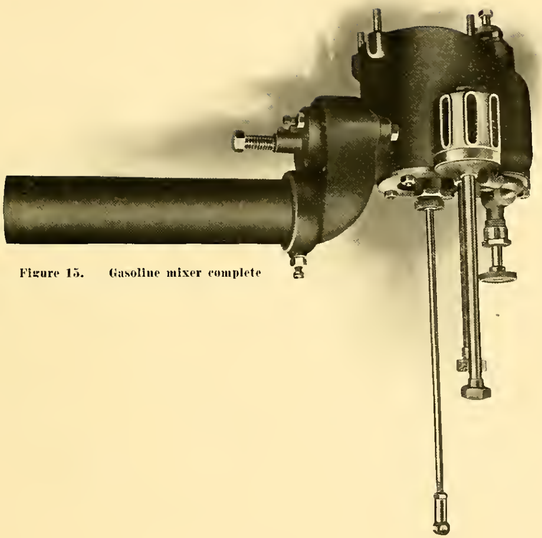

Figure 15. Gasoline mixer complete

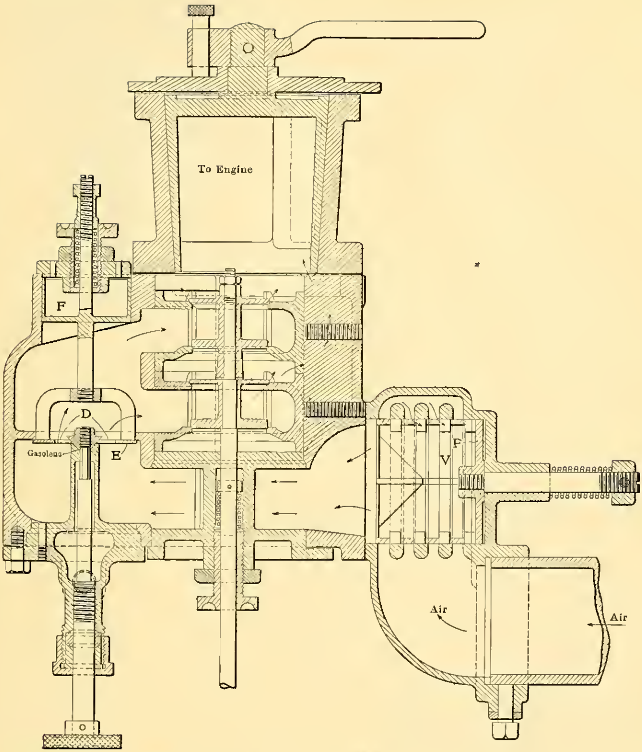

Figure 14. Sectional view of gasoline valve and mixer.

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COMPRESSED AIR STARTER. The engine is started on compressed air and passes first through a rotary valve running on one end of the cam shaft. This valve lets air into one cylinder every revolution. A pipe connects the valve and a part in the intake manifold under the cone valve. The throwing up of the starting lever, after the engine has started, unseats the rotary valve, thus reducing friction and wear. There is a three way valve on the intake manifold which is made so that either cylinder may be run independently, and this valve can be set so that for starting compressed air enters one cylinder only while the explosive mixture enters the explosion chamber.

Compression relief cams, operated by levers are provided so that in starting, they can be thrown in until the engine has picked up.

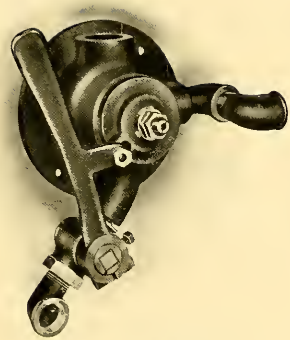

Figure 19. Air starting valve

Timing Diagram
of
Cylinder No. I.

Timing Diagram
of
Cylinder No. II.

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INSTALLATION

The engine as received from the manufacturer was completely assembled, with the exception of the fly wheels. A template of the base was first made, and then a concrete foundation made four feet three inches long by three feet six inches wide by one foot six inches high, with the bolts set in through it and two feet into the floor ofthe laboratory. This allowed the fly wheels to turn outside of the base at a distance of six inches from the floor. After the engine was set on this foundation, grout was forced in under it and it was then bolted down to make it absolutely solid. After allowing this to set for some days, the fly wheels were bolted and keyed into position.

The water for cooling was tapped from the city mains, the pressure of which forces the water through the water jacketing and out into either of two tanks set on scales, for determining the amount used. The outlet and inlet pipes

to the engine are fitted with brass thermometer cups, for determining the range of temperature through which the water is raised.

For starting purposes an air line was run from the compressed air storage tank, already installed for use with other apparatus. This line was of one inch pipe and was run along the wall until opposite the engine, where it was brought down and run under the floor directly under the air valve on the engine, and connected at this point. A valve was put on this line at a convenient point near the engine to prevent leakage through the engine valve which was found to be rather loose.

A tank was put at the gasoline pump end of the engine and the two gasoline pipes dropped into it and held in such a manner that they did not touch the tank. This tank was rigged so it could be set on a small set of scales for the purpose of weighing the gasoline used.

TEST OF I. H. C. GASOLINE ENGINE

SPECIAL APPARATUS

INDICATOR REDUCING GEAR. In designing the reducing gear for driving the gas engine indicators, the main object was to eliminate as much as possible, the errors in the cards due to backlash, looseness, stretching of the strings, etc. The gear as it was finally designed, consisted of a small shaft on the exhaust side of the engine, driven at engine speed by means of a Renold silent chain, the final drive being by means of an eccentric and cross head.

A specially designed shelf was mounted on the crank case at the air valve end of the motor. This shelf projects out nearly to the fly wheel and is on the proper level so that when the auto sparker is mounted upon it the friction wheel runs on the rim of the fly wheel. This arrangement places the auto sparker directly above the engine shaft, and

out of the way of any dirt or moisture. The intensifying coil and control switch are also placed on the shelf, greatly simplifying the wiring.

A small cast iron bracket four inches high is bolted on the outer right hand corner of the shelf and supports the outer end of the indicator drive shaft. Another cast iron bracket fifteen inches high is bolted on the shelf at the inner right hand corner. A third bracket twenty inches higher up supports the other end of the indicator drive shaft. This third bracket is bolted on to the top of the crank case at the gasoline pump end of the engine.

The shaft, which is five eighths of an inch in diameter, runs in three specially designed pillow blocks bolted on to the vertical brackets. The shaft is mounted so that it passes by the cylinders, on the exhaust side, just above the inlet water manifold.

This counter shaft is driven from the crank shaft of the engine by means of a Renold silent chain of one half inch pitch by one half inch width. The sprocket wheels for the chain are of the same diameter and one half inch pitch, the outside diameter being six and three eights inches. The driver sprocket is keyed on to the main shaft between the fly wheel and the end of the crank case. The driven sprocket is fastened on to the end of the indicator drive shaft outside of the end bearing.

The final drive to the indicators is by eccentrics and cross head. The eccentrics are of cast iron, with manganese bronze eccentric straps. The eccentrics are fastened to the shaft by means of set screws, and are located just to the left of each of the two main brackets. A nine thirty secons inch rod running between bronze guides carries the cross head wrist pin of the cross head. It also has fastened to it a finger about three inches long,

projecting in at right angles to the cross head rod. This finger is in such a position that the indicator cord can be readily hooked on to it while the engine is running. The eccentric strap is connected to the wrist pin by a short steel rod which is screwed into the top of the eccentric strap at one end and the wrist pin bearing at the other.

PRONY BRAKE. The power developed by the engine was absorbed by means of a specially designed prony brake. The brake pulley is a heavy iron casting twenty four inches in diameter, having a deep flange or lip on the inside to contain the cooling water. The brake pulley is bolted directly on to the lugs on the spokes of one of the fly-wheels.

The brake shoes consist of two heavy blocks of wood, each having an arc of contact of about three eights of the pulley circumference. Each shoe is made up of seven, inch and one eight pine boards, three feet long and twelve inches

wide, set on edge and bolted together. In order to make the shoes very rigid a quarter inch steel plate thirty six inches long by eight and one-half inches wide, was screwed on to the top of each brake shoe.

The brake arm is made up of one and one-quarter inch pipe and pipe fittings in the form of a closed Y with the point of closure of the two sloping sides on the central axis of the brake. The two halves of the brake are held together by two seven eight inch bolts, three feet long. One bolt is threaded through the straight pipe of the brake arm and supports it. Pressure is applied by screwing down hand wheels threaded on to the bolts. The effective brake arm is designed to be five feet three inches long, this giving a brake circumference of thirty-three feet, which greatly simplifies the calculations. The dead weight of the brake on the scales is twenty-two pounds.

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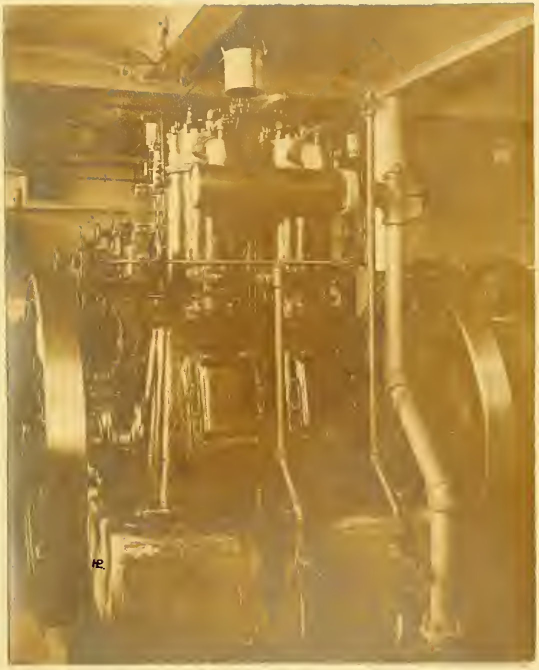
The power absorbed by the brake is turned into heat by the friction of the shoe on the pulley. This heat in turn is taken up by the cooling water in the brake. The cooling water is sprayed in through a one-quarter inch pipe and is controlled by a valve. A three-quarter inch pipe connected to the sewer is so placed that it will scoop out the water in the pulley when it reaches a certain level.



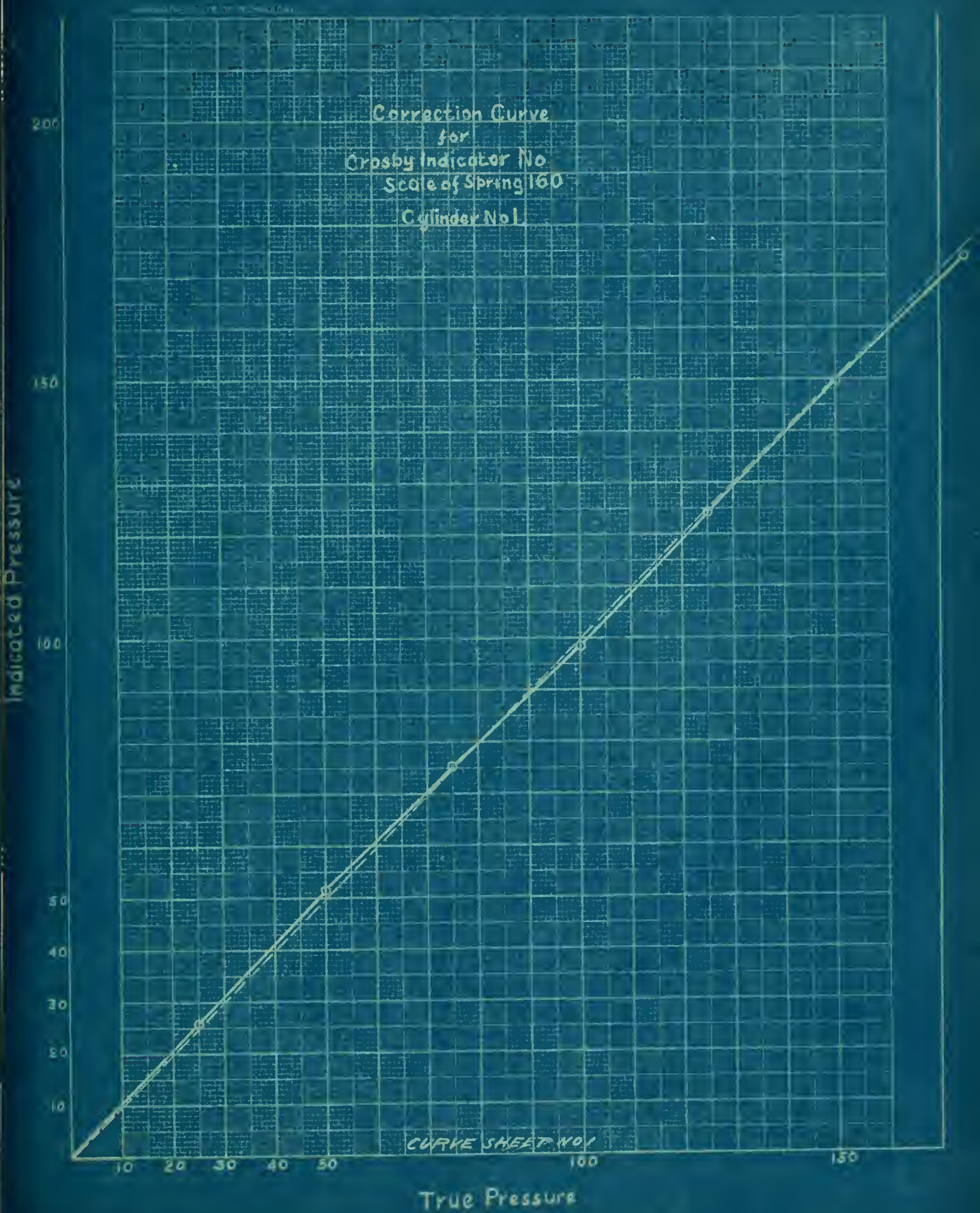
TEST OF I. H. C. GASOLINE ENGINE

CALIBRATION OF INDICATOR SPRINGS

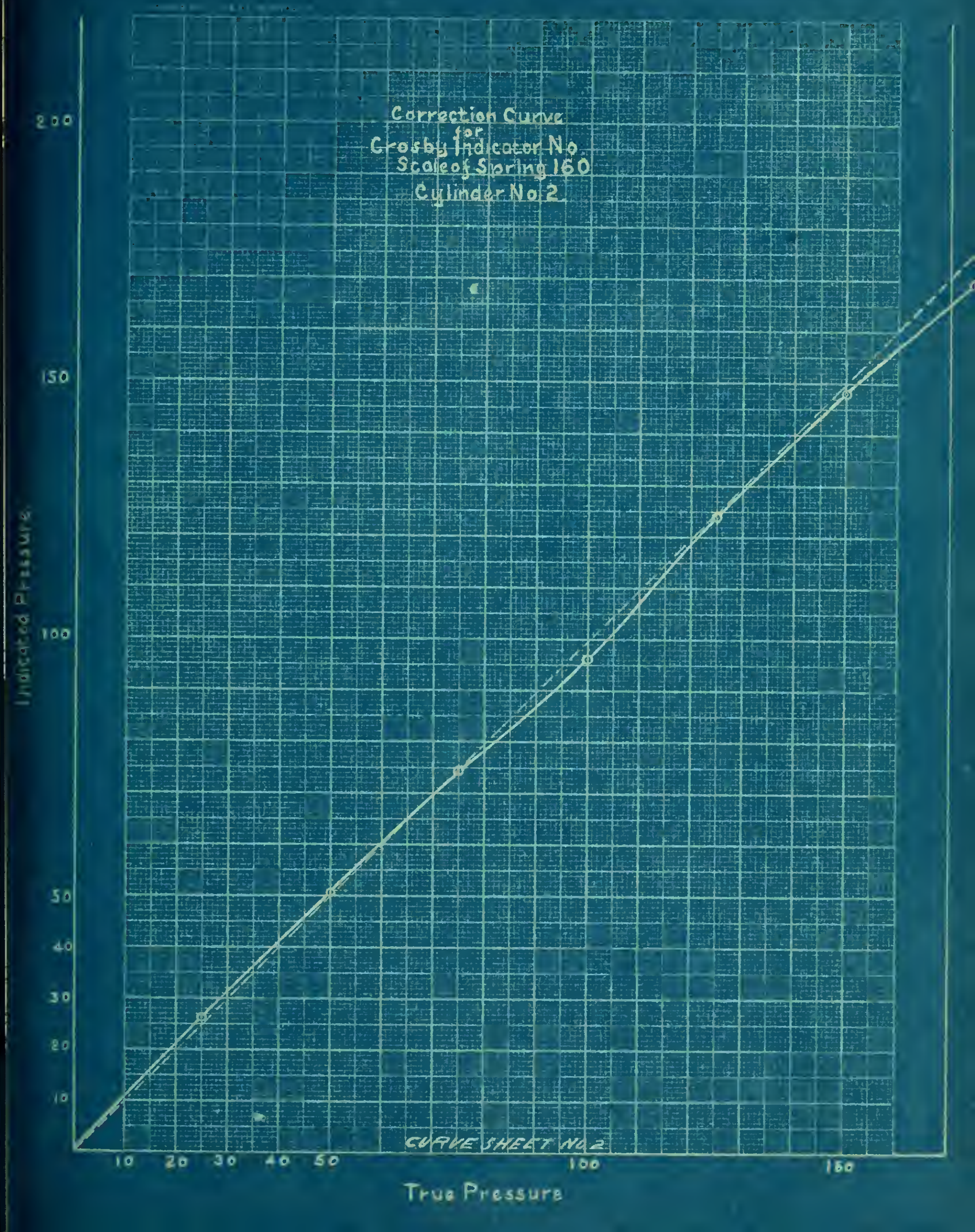
The indicators which we used were of the Crosby type and for the pressures developed, 160 pound springs were found to give the best cards.

We calibrated these springs by air pressure. For this purpose a fitting was made consisting of three ~~and~~ one-half inch tees connected in a line of nipples. One end of this fitting was connected to the air line and on the other a valve was connected to regulate the pressure. Into two of the tees the indicators were screwed and into the third, and between the indicators, a calibrated guage was placed. Then air was let into the pipe and horizontal lines drawn on the indicator cards for every ten pound increment of pressure until a maximum was reached and then back again by ten pound stages to zero.

A curve was plotted of the results, and was found to vary so little that the indicator springs were called correct as found.


Correction Curve
for
Crosby Indicator No
Scale of Spring 160
Cylinder No 1
Indicated Pressure
True Pressure
CURVE SHEET NO 1
10
20
30
40
50
100
150
200

[illegible]



Correction Curve
for
Crosby Indicator No
Scale of Spring 160
Cylinder No 2
200
150
100
50
40
30
20
10
Indicated Pressure
CURVE SHEET No 2
10
20
30
40
50
100
150
True Pressure

TEST OF I. H. C. GASOLINE ENGINE

DETERMINATION OF THE CALORIFIC VALUE OF GASOLINE

The determination of the calorific value of gasoline was made as follows:-

The Mahler Bomb calorimeter was the apparatus used. It consists of a strong steel vessel, provided with a tightly fitting cover into which the fuel is placed for combustion and to help this combustion oxygen is supplied to the vessel under a pressure of twenty-five atmospheres. The fuel is supported by a cage of platinum connected to the cover and is fired by an electric current passing through connecting wires to the electric lighting circuit. This bomb is lined with porcelain to prevent oxidation. The bomb before being fired is placed in a known amount of water and the rise of temperature during combustion multiplied by the change in temperature as recorded by the Beckman thermometer gives the B. T. U. generated by the fuel. Before and after firing, the temperature of the water is noted for five minutes so that the calorimeter can be corrected for radiation.

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In the tests we made it was thought advisable to absorb the gasoline used in the calorimeter in naphthalene, whose B. T. U. per pound is constant, to prevent rapid vaporization, and danger of spilling, in handling the charge. The naphthalene was weighed and put in the firing pan and then a known amount of gasoline put over it by means of a pipette reading to one-one hundredth of a c. c. and the lid quickly screwed on to prevent the gasoline from escaping. Knowing the B. T. U. and weight of the naphthalene, the amount of gasoline and the weight and rise in temperature of the bomb, the calorific value of gasoline can then be determined.

TEST OF I. H. C. GASOLINE ENGINE

SAMPLE COMPUTATION OF CALORIFIC

DETERMINATION OF GASOLINE

Weight of Pan - - - - - - - - - - 6,1404 gms.

Weight of Pan plus Naphthalene 7,2301 gms.

Weight of Naphthalene - - - - - 1,0897 gms.

Calorific Value - - - 9692 B.T.U. per gram.

Reading of Pipette full - - - - .05 C. C.

Reading of Pipette empty- - - - .66 C. C.

Volume of Gasoline - - - - - - .61 C. C.

Volume of Water in Bomb- - - - 2200 C. C.

Water Equivalent of Bomb - - - 512 C. C.

Total Volume, - - - - - - - - 2712 C. C.

READINGS TAKEN ON BECHMAN

THERMOMETER EVERY 30 SECONDS.

Before Firing:	During Combustion:	After Combustion
.448		6.07
.45	2.00	6.07
.457	5.00	6.07
.457	6.07	6.065
.46	6.08	6.05
.468		6.04
.47		6.03
.476		6.02
.478		6.01
.480		6.00

TEST OF I. H. C. GASOLINE ENGINE

CALORIFIC VALUE OF GASOLINE

$$\begin{array}{r} .480 \\ \underline{.448} \\ 10)\overline{.032} \\ .0032 \end{array}$$

.0032 Radiation for 30 sec.before combustion.

$$\begin{array}{r} 6.00 \\ \underline{6.08} \\ 10)\overline{\ .08} \\ .008 \end{array}$$

.008 Radiation for 30 sec.after combustion.

Take before combustion readings for one minute from after combustion readings for one and one-half minutes to get average radiation.

$$\begin{array}{rr} .0032 & .008 \\ \underline{2} & \underline{3} \\ .0064 & .024 \end{array} \quad .024-.0064=.0178^{\circ} \text{ radiation correction.}$$

$$\begin{array}{rl} 6.08 & \text{Reading after conbustion} \\ \underline{.48} & \text{Reading before combustion} \\ 5.60^{\circ} & \text{Raise in temperature} \\ \underline{.0178} & \text{Radiation correction} \\ 5.6178 & \text{Total Rise of Water in Bomb.} \end{array}$$

5.6178 x 2712 = 15235.474 B.T.U.obtained in Bomb

1.0897 x 9692 = 10561.37 B.T.U.of Naphthalene in Bomb

4674.1 B.T.U.of Gasoline in Bomb.

Gasoline tested had a volume of .61 C. C.

$\therefore$ 4674.1 ÷ .61 = 7662.5 B.T.U. of gasoline per C.C.

TEST OF I. H. C. GASOLINE ENGINE

CALORIFIC VALUE OF GASOLINE

Gasoline tested had a specific gravity of .7319

.˙. 7662.5 ÷ .7319 = 10,469 B.T.U. per gram.

1 B.T.U. per pound = 1.8 B.T.U. per gram

.˙. 10,469 x 1.8 = 18,846 B.T.U. per pound

is calorific value of gasoline tested.

The average for all specimens on run A - K

was 18,850 B.T.U. - On runs K - Z 19,000 B.T.U.

TEST OF I. H. C. GASOLINE ENGINE

SAMPLE CALCULATIONS OF

LOG SHEET

Run #C.

$$B.H.P. = \frac{2\pi lnw}{33,000} = \frac{33.323.5.77.3}{33,000} = 25 \text{ H. P.}$$

$$I.H.P. = \frac{P\ L\ A\ N}{33,000} = \frac{80.\frac{10}{12}.\ .(4)^2.323.5}{33,000} = 34.07$$

$$\text{Mech. Eff.} = \frac{25}{34.07} = 73.4\%$$

Gasoline per B.H.P. per hour. 1 Gal.Gasoline= 6 lbs.

$$= \frac{\text{lbs.}}{6xHP} = \frac{18.73}{6x25} = .1247 \text{ Gallons.}$$

B.T.U. supplied - lbs gasoline x heat value per lb.

$$= 18.73 \times 18.850 = 353,050 \text{ B.T.U.}$$

B.T.U. per I.H.P. per hour

$$= \frac{\text{Total heat}}{\text{I. H. P.}} = \frac{354,050}{34.07} = 10,350 \text{ B.T.U.}$$

B.T.U. per B.H.P. per hour

$$= \frac{\text{Total Heat}}{\text{B.H.P.}} = \frac{353,050}{25} = 14,125 \text{ B.T.U.}$$

$$\text{Thermal Efficiency per I.H.P.} = \frac{10,350}{2545} = 24.6\%$$

$$\text{Thermal Efficiency per B.H.P.} = \frac{14,125}{2545} = 18\%$$

$$\text{Ideal Thermal Efficiency} = 1-\left(\frac{V_d}{V_c}\right)^{k-1} = 1\left(\frac{158}{660.6}\right)^{1.405-1}$$

V_d = 158 cu.in.

V_c = 660.66 cu.in.

K = 1.405

$$=1-.24^{.405} = 1-.562=.438 \text{ or } 43.8\%$$

TEST OF I. H. C. GASOLINE ENGINE

Run C Continued.

Ratio I. H. P. eff to Ideal Eff. $= \frac{24.6}{43.8} = 56.1\%$

Ratio B. H. P. eff to Ideal Eff. $= \frac{18}{43.8} = 41\%$

Heat Balance

		B.T.U.	%
Heat Supplied = 353,050 B. T. U.			
Heat Equivalent of I.H.P.	=2545.34.07=	86,700;	24.6
Heat Rejected in Jacket Water	=5043.23.5=	118,500;	33.6
Heat Lost in Exhaust, etc.		147,750;	41.8
		353.050;	100

TEST NO. I

EFFICIENCY TESTS AT VARIOUS BRAKE LOADS

TEST OF I. H. C. GASOLINE ENGINE

TEST FOR EFFICIENCY AT VARIOUS BRAKE LOADS. The first series of tests which we ran was to determine the efficiency of the engine at various brake loads throughout its range of power. These tests were for the purpose of getting some results with which we could compare our other results, as well as to get acquainted with the finer details in the running and regulation of the engine.

We found that in this engine, as in all gasoline engines, the thermal efficiency is poor at all loads except those very near the rated horse power. This can be readily seen by referring to curve sheet No. (4) where it will be noted that the slope of the thermal efficiency curve shows that it makes it extremely uneconomical to run the engine at any but its rated horse power. At this point the thermal efficiency was found to be 20% which is extremely good for this type of engine.

TEST OF I. H. C. GASOLINE ENGINE

Within the range of power of this engine the mechanical efficiency rises rapidly as the load increases until the rated horse power is reached, when it rises slowly to the maximum power of the engine. This shows that the frictional horse power is nearly constant at all loads. This can also be seen by referring to curve sheet No. (4), the maximum mechanical efficiency being 80%. This compares favorably with the figures obtained from other good makes of internal combustion engines.

Especial attention is called to curve sheet No. (3) from which it can readily be seen that the gasoline consumption is enormous if the engine is run on light loads, but that on loads ranging from twenty to twenty-eight horse power the engine is extremely economical. At twenty-five horse power the gasoline consumption is better than one-ninth of a gallon per Horse Power hour. This is lower than is usually found

in similar instances, one-eighth of a gallon being considered a low gasoline consumption.

The other item which we examined into was the compression and explosive pressures and these were both found to increase rapidly with the load on the engine. This is caused by the throttle valve opening wider on high loads and consequently allowing the weight of gas in the cylinders at inlet closure to become greater. Hence the compression is greater and also the explosion pressure. This is drawn out in curve form in Plate No. (5).

TEST OF I. H. C. GASOLINE ENGINE
Armour Institute of Technology

April 20, 1911.

Type: Victor Two Cylinder Vertical.

Fuel Used: Gasoline.

Builders Rating: 25 H. P. at 325 R.P.M.

Bore: 8". Stroke: 10". Clearance: 31.5% Piston Displacement

Brake Circumference, 33 ft. Indicator Used: Crosby.

Dead Weight of Arm, 22 lbs. Scale Spring: 160#.

Object of Test: Efficiency Tests at Various Brake Loads.

RUN NO.		M
Duration of Test	hours	1
Revolutions per Minute		370
Net Brake Load	lbs.	0
Actual Brake Horse Power		0
DATA FROM CARDS		
a Maximum Pressure, lbs. per Sq. In.		43
b Compression Pressure, lbs. per Sq. In.		17
c Mean Effective Pressure, lbs. per Sq. In. Cyl. 1		20.1
" " " " " " " Cyl. 2		25.4
Indicated Horse Power		5.34
Frictional Horse Power		5.34
Mechanical Efficiency	lbs.	0
Gasoline per Hour		9.50
Gallons per Horse Power Hour		
Calorific Value of Gasoline per lb.	B.T.U.	19,000
Jacket Water per Hour	lbs.	1284
Inlet Cooling Water	Deg.F.	48.5
Outlet Cooling Water	Deg.F.	123
Range of Temperature	Deg.F.	74.5

TEST OF I. H. C. GASOLINE ENGINE
Armour Institute of Technology

RUN NO.		M
Air in Room		70
Barometric Pressure	Ins.Hg.	29.51
B. T. U. per I. H. P. per Hour		33,800
B. T. U. per B. H. P. per Hour		
Thermal Efficiency per I. H. P.	%	7.53
Thermal Efficiency per B. H. P.	%	
Ideal Thermal Efficiency	%	43.8
Ratio of I. H. P. Efficiency to Ideal eff.	%	17.2
Ratio of B. H. P. Efficiency to Ideal eff.	%	
HEAT BALANCE		
Heat Supplied	B.T.U.	180,500
Heat Supplied	%	100
Heat Equivalent of I. H. P.	B.T.U.	13,600
Heat Equivalent of I. H. P.	%	7.5
Heat Rejected in Jacket Water	B.T.U.	95,800
Heat Rejected in Jacket Water	%	53
Heat Lost in Exhaust, Radiation, etc.,	B.T.U.	71,500
Heat Lost in Exhaust, Radiation, etc.,	%	39.5
Temperature of Air in Intake Pipe	Deg.F.	101
Temperature of Gas in Intake Manifold	Deg.F.	82

TEST OF I. H. C. GASOLINE ENGINE
Armour Institute of Technology

April 19, 1911.

Type: Victor Two Cylinder Vertical.

Fuel Used: Gasoline.

Builders Rating: 25 H. P. at 325 R.P.M.

Bore: 8". Stroke: 10". Clearance: 31.5% Piston Displacement.

Dead Weight of Arm, 22 lbs. Indicator Used: Crosby.

Brake Circumference, 33 ft. Scale Spring: 160#.

Object of Test: Efficiency of Various Brake Loads.

RUN NO.		I
Duration of Test	hours	1
Revolutions Per Minute		340
Net Brake Load	lbs.	5
Actual Brake Horse Power		
DATA FROM CARDS		
a Maximum Pressure, lbs. per Sq. In.		42
b Compression Pressure, lbs. per Sq. In.		23
c Mean Effective Pressure, lbs. per Sq. In.	Cyl. 1	32
" " " " " " "	Cyl. 2	23.8
Indicated Horse Power		11.9
Frictional Horse Power		6.5
Mechanical Efficiency	%	42
Gasoline per Hour	lbs.	14.2
Gallons per Horse Power Hour		.4.74
Calorific Value of Gasoline per lb.	B.T.U.	18,850
Jacket Water per Hour	lbs.	1111
Inlet Cooling Water	Deg.F.	47
Outlet Cooling Water	Deg.F.	113
Range of Temperature	Deg.F.	66

TEST OF I. H. C. GASOLINE ENGINE
Armour Institute of Technology

RUN NO.		I
Air in Room		75
Barometric Pressure	Ins.Hg.	29.56
B. T. U. per I. H. P. per Hour		22,500
B. T. U. per B. H. P. per Hour		53,500
Thermal Efficiency per I. H. P.	%	11.4
Thermal Efficiency per B. H. P.	%	2.1
Ideal Thermal Effieiency	%	43.8
Ratio of I. H. P. Efficiency to Ideal eff.	%	26
Ratio of B. H. P. Efficiency to Ideal eff.	%	4.8
HRAT BALANCE		
Heat Supplied	B.T.U.	257,500
Heat Supplied	%	100
Heat Equivalent of I. H. P.	B.T.U.	30,300
Heat Equivalent of I. H. P.	%	11.4
Heat Rejected in Jacket Water	B.T.U.	73,400
Heat Rejected in Jacket Water	%	28.6
Heat Lost in Exhaust, Radiation, etc.,	B.T.U.	153,800
Heat Lost in Exhaust, Radiation, etc.,	%	60
Temperature of Air in Intake Pipe	Deg.F.	83
Temperature of Gas in Intake Manifold	Deg.F.	102

TEST OF I. H. C. GASOLINE ENGINE
Armour Institute of Technology

April 25, 1911.

Type: Victor Two Cylinder Vertical.

Fuel Used: Gasoline.

Builders Rating: 25 H. P. at 325 R.P.M.

Bore: 8". Stroke: 10". Clearance; 31.5% Piston Displacement.

Brake Circumference, 33 ft. Indicator Used: Crosby.

Dead Weight of Arm, 22 lbs. Scale Spring: 160#.

Object of Test: Efficiency Test at Variour Brake Loads.

RUN NO.		T
Duration of Test	hours	1
Revolutions per Minute		340
Net Brake Load	lbs.	29.5
Actual Brake Horse Power		10
DATA FROM CARDS		
a Maximum Pressure, lbs. per Sq. In.		94.3
b Compression Pressure, lbs. per Sq. In.		20.8
c Mean Effective Pressure, lbs. per Sq. In. Cyl. 1		38.1
" " " " " " " Cyl. 2		42.9
Indicated Horse Power		17.48
Frictional Horse Power		7.48
Mechanical Efficiency	%	57.3
Gasoline per Hour	lbs.	14.80
Gallons per Horse Power Hour		.247
Calorific Value of Gasoline per lb.	B.T.U.	18,000
Jacket Water per Hour		1268
Inlet Cooling Water	Deg.F.	49
Outlet Cooling Water	Deg.F.	129
Range of Temperature	Deg.F.	80

TEST OF I. H. C. GASOLINE ENGINE
Armour Institute of Technology

RUN NO.		T
Air in Room		70
Barometric Pressure	Ins.Hg.	29.56
B. T. U. per I. H. P. per Hour		16,100
B. T. U. per B. H. P. per Hour		28,100
Thermal Efficiency per I. H. P.	%	15.85
Thermal Efficiency per B. H. P.	%	11.00
Ideal Thermal Efficiency	%	43.8
Ratio of I. H. P. Efficiency to Ideal eff.	%	36.3
Ratio of B. H. P. Efficiency to Ideal eff.	%	25.2
HEAT BALANCE		
Heat Supplied	B.T.U.	281,000
Heat Supplied	%	100
Heat Equivalent of I. H. P.	B.T.U.	44,600
Heat Equivalent of I. H. P.	%	15.85
Heat Rejected in Jacket Water	B.T.U.	100,500
Heat Rejected in Jacket Water	%	35.8
Heat Lost in Exhaust, Radiation, etc.,	B.T.U.	135,900
Heat Lost in Exhaust, Radiation, etc.,	%	48.35
Temperature of Air in Intake Pipe	Deg.F.	85
Temperature of Gas in Intake Manifold	Deg.F.	103

TEST OF I. H. C. GASOLINE ENGINE
Armour Institute of Technology

April 18, 1911.

Type: Victor Two Cylinder Vertical.
Fuel Used: Gasoline.

Builders Rating: 25 H. P. at 325 R.P.M.

Bore: 8". Stroke: 10". Clearance: 31.5% Piston Displacement

Brake Circumference, 33 ft. Indicator Used: Crosby.

Dead Weight of Arm, 22 lbs. Scale Spring: 160#.

Object of Test: Efficiency Tests at Various Brake Loads.

RUN NO.		H
Duration of Test	hours	1
Revolutions per Minute		332
Net Brake Load	lbs.	45.2
Actual Brake Horse Power		15
DATA FROM CARDS		
a Maximum Pressure, lbs. per Sq. In.		108.
b Compression Pressure, lbs. per Sq. In.		37.5
c Mean Effective Pressure, lbs. per Sq. In. Cyl. 1		54.86
" " " " " " " Cyl. 2		58.12
Indicated Horse Power		23.74
Frictional Horse Power		8.74
Mechanical Efficiency	%	63.2
Gasoline per Hour	lbs.	14.00
Gallons per Horse Power Hour		.1555
Calorific Value of Gasoline per lb.	B.T.U.	18,880
Jacket Water per Hour		1524
Inlet Cooling Water	Deg.F.	45
Outlet Cooling Water	Deg.F.	109.6
Range of Temperature	Deg.F.	64.6

TEST OF I. H. C. GASOLINE ENGINE
Armour Institute of Technology

RUN NO.		H
Air in Room		70
Barometric Pressure	Ins.Hg.	29.52
B. T. U. per I. H. P. per Hour		11.110
B. T. U. per B. H. P. per Hour		17,600
Thermal Efficiency per I. H. P.	%	22.9
Thermal Efficiency per B. H. P.	%	14.45
Ideal Thermal Efficiency	%	43.8
Ratio of I. H. P. Efficiency to Ideal eff.	%	52.2
Ratio of B. H. P. Efficiency to Ideal eff.	%	33
HEAT BALANCE		
Heat Supplied	B.T.U.	264,000
Heat Supplied	%	100
Heat Equivalent of I. H. P.	B.T.U.	60,400
Heat Equivalent of I. H. P.	%	22.9
Heat Rejected in Jacket Water	B.T.U.	98,500
Heat Rejected in Jacket Water	%	37.3
Heat Lost in Exhaust, Radiation, etc.,	B.T.U.	105,000
Heat Lost in Exhaust, Radiation, etc.,	%	39.8
Temperature of Air in Intake Pipe	Deg.F.	104
Temperature of Gas in Intake Manifold	Deg.F.	89

TEST OF I. H. C. GASOLINE ENGINE
Armour Institute of Technology

April 20, 1911.

Type: Victor Two Cylinder Vertical.

Fuel Used: Gasoline.

Builders Rating: 25 H. P. at 325 R.P.M.

Bore: 8". Stroke: 10". Clearance: 31.5% Piston Displacement.

Brake Circumference, 33 ft. Indicator Used: Crosby.

Dead Weight of Arm, 22 lbs. Scale Spring: 160#.

Object of Test: Efficiency Tests at Various Brake Loads.

RUN NO.		N
Duration of Test	hours	1
Revolutions per Minute		330
Net Brake Load	lbs.	60
Actual Brake Horse Power		20
DATA FROM CARDS		
a Maximum Pressure, lbs. per Sq. In.		52.8
b Compression Pressure, lbs. per Sq. In.		12.4
c Mean Effective Pressure, lbs. per Sq. In. Cyl. 1		58
" " " " " " " Cyl. 2		67.4
Indicated Horse Power		26.2
Frictional Horse Power		6.2
Mechanical Efficiency	%	76.4
Gasoline per Hour	lbs.	15.67
Gallons per Horse Power Hour		.115
Calorific Value of Gasoline per lb.	B.T.U.	19,000
Jacket Water per Hour		1518
Inlet Cooling Water	Deg.F.	46
Outlet Cooling Water	Deg.F.	112
Range of Temperature	Deg.F.	66

TEST OF I. H. C. GASOLINE ENGINE
Armour Institute of Technology

RUN NO.		N
Air in Room		70
Barometric Pressure	Ins.Hg.	29.56
B. T. U. per I. H. P. per Hour		11,330
B. T. U. per B. H. P. per Hour		14,850
Thermal Efficiency per I. H. P.	%	22.5
Thermal Efficiency per B. H. P.	%	17.8
Ideal Thermal Efficiency	%	43.8
Ratio of I. H. P. Efficiency to Ideal eff.	%	56.3
Ratio of B. H. P. Efficiency to Ideal eff.	%	40.8
HEAT BALANCE		
Heat Supplied	B.T.U.	297,000
Heat Supplied	%	100
Heat Equivalent of I. H. P.	B.T.U.	66,700
Heat Equivalent of I. H. P.	%	22.5
Heat Rejected in Jacket Water	B.T.U.	100,000
Heat Rejected in Jacket Water	%	33.7
Heat Lost in Exhaust, Radiation, etc.,	B.T.U.	130,300
Heat Lost in Exhaust, Radiation, etc.,	%	43.8
Temperature of Air in Intake Pipe	Deg.F.	102
Temperature of Gas in Intake Manifold	Deg.F.	82

TEST OF I. H. C. GASOLINE ENGINE
Armour Institute of Technology

April 21,1911.

Type: Victor Two Cylinder Vertical.

Fuel Used: Gasoline.

Builders Rating: 25 H. P. at 325 R.P.M.

Bore: 8". Stroke: 10". Clearance: 31.5% Piston Displacement.

Brake Circumference, 33 ft. Indicator Used: Crosby.

Dead Weight of Arm, 22 lbs. Scale Spring: 160#.

Object of Test: Varying Temperature of Jacket Water.

RUN NO.		0
Duration of Test	hours	1
Revolutions per Minute		325
Net Brake Load	lbs.	77
Actual Brake Horse Power		25
DATA FROM CARDS		
a Maximum Pressure, lbs. per Sq. In.		204
b Compression Pressure, lbs. per Sq. In.		27.5
c Mean Effective Pressure, lbs. per Sq. In. Cyl. 1		74.9
" " " " " " " Cyl. 2		84.3
Indicated Horse Power		32.7
Frictional Horse Power		7.7
Mechanical Efficiency		76.6
Gasoline per Hour		16.8
Gallons per Horse Power Hour		.112
Calorific Value of Gasoline per lb.	B.T.U.	19,000
Jacket Water per Hour		610
Inlet Cooling Water	Deg.F.	52.40
Outlet Cooling Water	Deg.F.	211.25
Range of Temperature	Deg.F.	158.85

TEST OF I. H. C. GASOLINE ENGINE
Armour Institute of Technology

RUN NO.		0
Air in Room		75
Barometric Pressure	Ins.Hg.	29.56
B. T. U. per I. H. P. per Hour		9,760
B. T. U. per B. H. P. per Hour		12,740
Thermal Efficiency per I. H. P.	%	26.1
Thermal Efficiency per B. H. P.	%	20
Ideal Thermal Efficiency	%	43.8
Ratio of I. H. P. Efficiency to Ideal eff.	%	59.5
Ratio of B.H. P. Efficiency to Ideal eff.	%	45.6
HEAT BALANCE		
Heat Supplied	B.T?U.	319,000
Heat Supplied	%	100
Heat Equivalent of I. H. P.	B.T.U.	83,400
Heat Equivalent of I. H. P.	%	26.1
Heat Rejected in Jacket Water	B.T.U.	96,800
Heat Rejected in Jacket Water	%	30.3
Heat Lost in Exhaust, Radiation, etc.,	B.T.U.	138,800
Heat Lost in Exhaust, Radiation, etc.,	%	43.6
Temperature of Air in Intake Pipe	Deg.F.	78
Temperature of Gas in Intake Manifold	Deg.F.	100

TEST OF I. H. C. GASOLINE ENGINE
Armour Institute of Technology

April 19, 1911.

Type: Victor Two Cylinder Vertical.

Fuel Used: Gasoline.

Builders Rating: 25 H. P. at 325 R.P.M.

Bore: 8". Stroke: 10". Clearance: 31.5% Piston Displacement.

Brake Circumference, 33 ft. Indicator Used: Crosby.

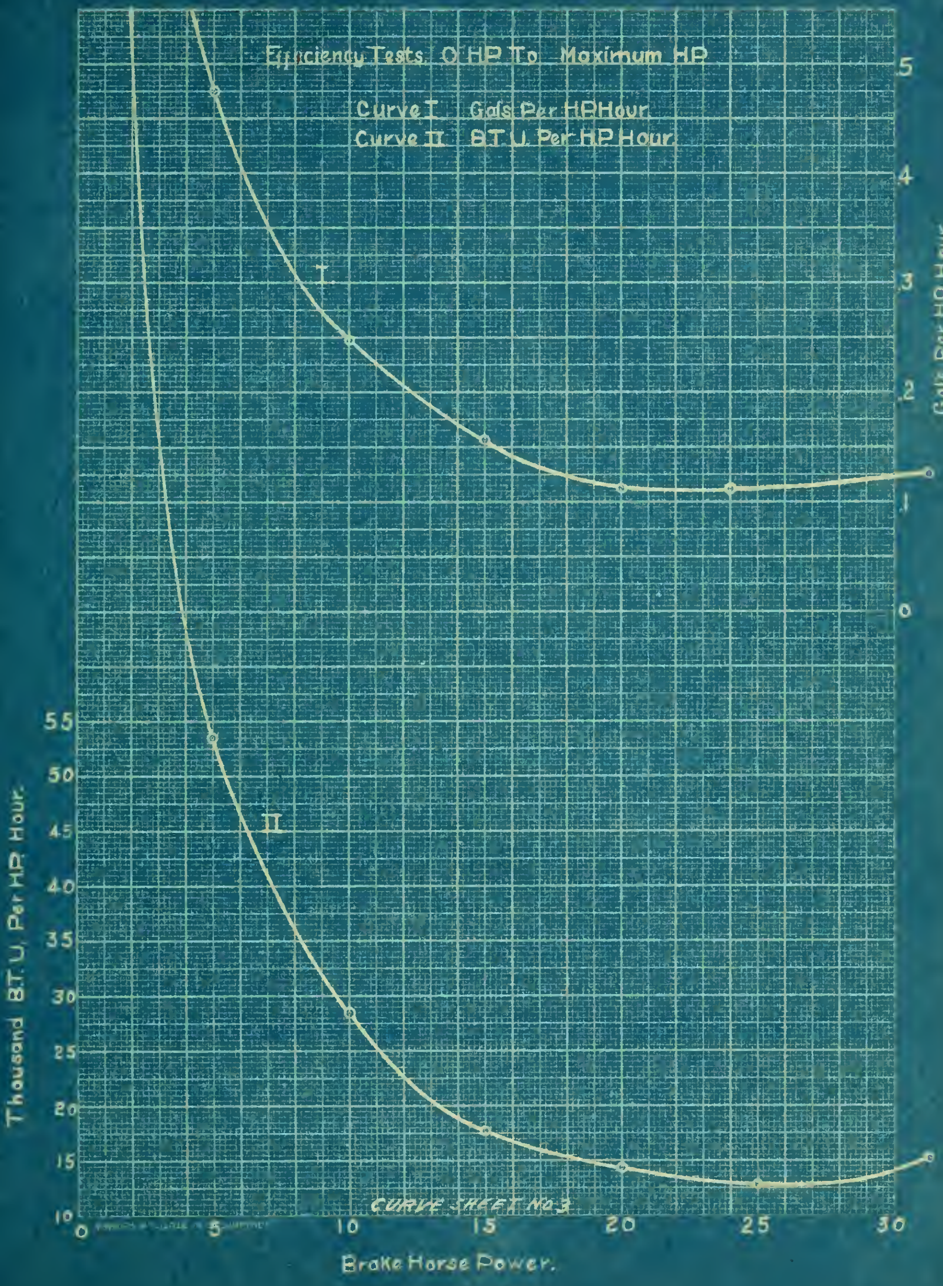
Dead Weight of Arm, 22 lbs. Scale Spring: 160#.

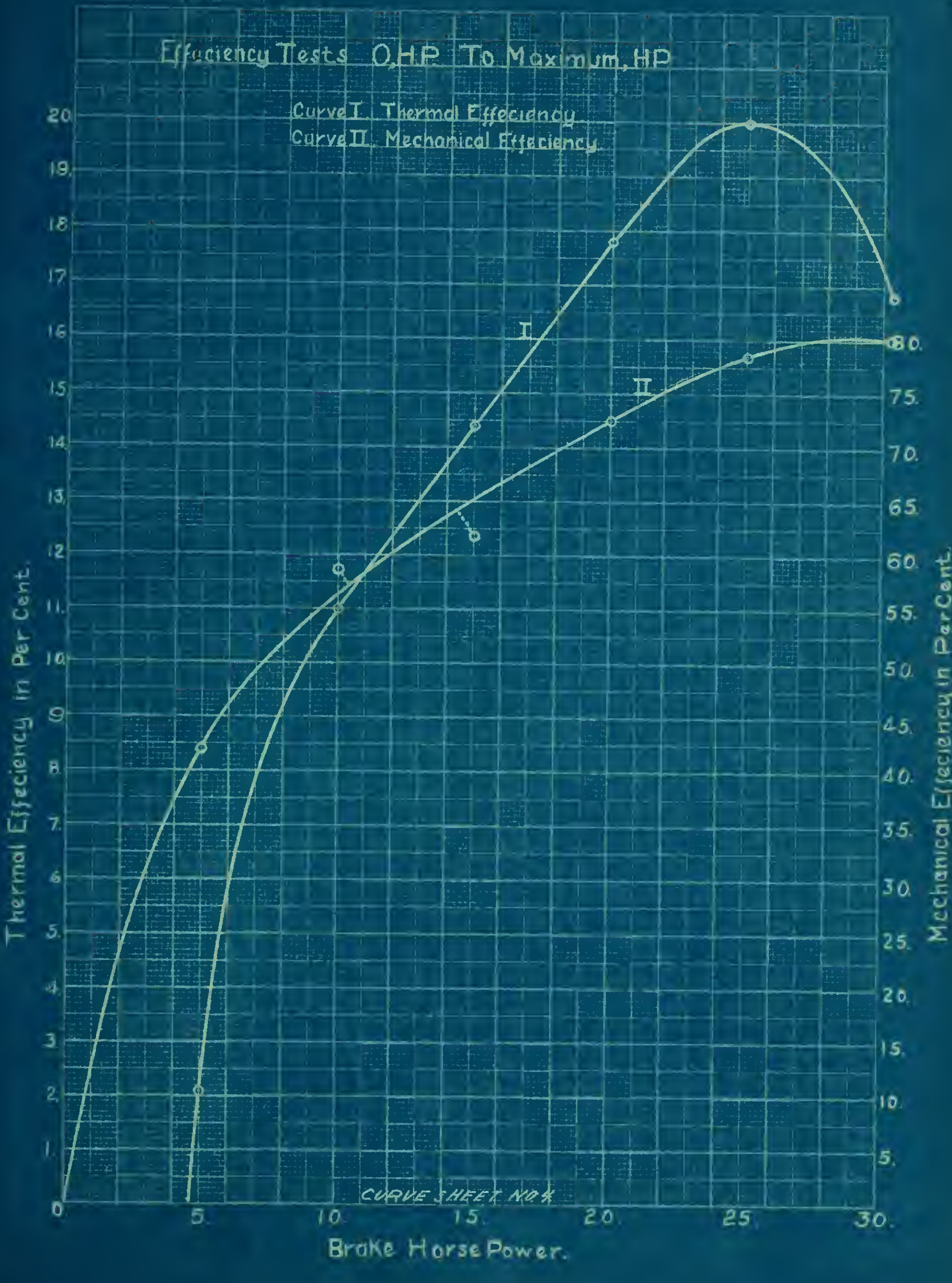
Object of Test: Efficiency Tests at Various Brake Loads.

RUN NO.		K
Duration of Test,	hours	1
Revolutions per minute		298.33
Net Brake Load	lbs.	106.85
Actual Brake Horse Power		31.83
DATA FROM CARDS		
a Macimum Pressure, lbs. per Sq. In.		340
b Compression Pressure, lbs. per Sq. In.		64
c Mean Effective Pressure, lbs. per Sq. In.	Cyl. 1	104.
" " " " " " "	Cyl. 2	108.7
Indicated Horse Power		40.3
Frictional Horse Power		8.47
Mechanical Efficiency	%	79.1
Gasoline per Hour	lbs.	25.40
Gallons per Horse Hour,		.125
Calorific Value of Gasoline per lb.	B.T.U.	19,000
Jacket Water per Hour,		1448
Inlet Cooling Water,	Deg.F.	46
Outlet Cooling Water	Deg.F.	135.4
Range of Temperature,	Deg.F.	89.4

TEST OF I. H. C. GASOLINE ENGINE
Armour Institute of Technology

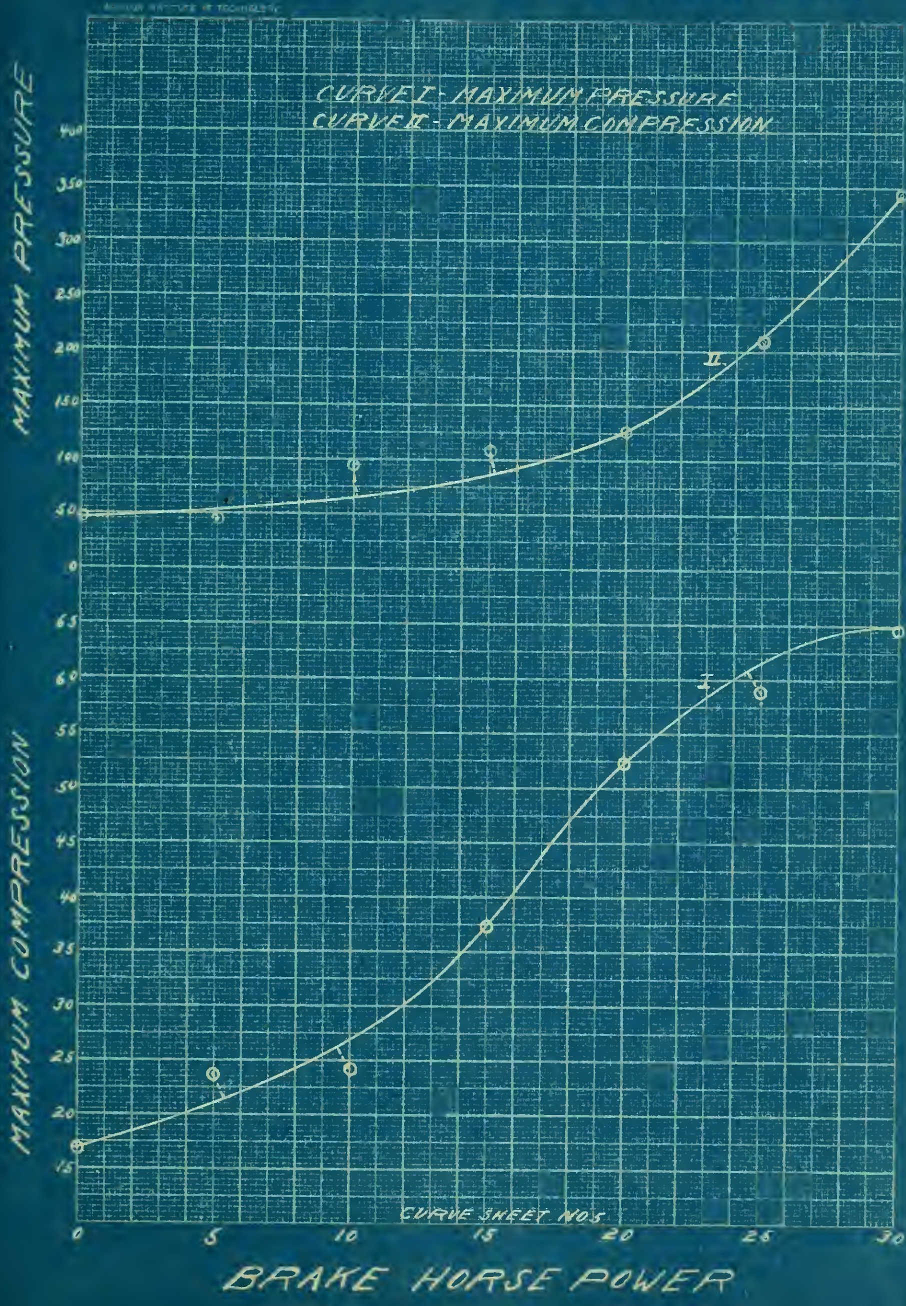
RUN NO.		K
Air in Room		70
Barometric Pressure,	Ins.Hg.	29.5
B. T. U. per I. H. P. per Hour		11,950
B. T. U. per B. H. P. per Hour		15,550
Thermal Efficiency per I. H. P.	%	21.3
Thermal Efficiency per B. H. P.	%	16.8
Ideal Thermal Efficiency	%	43.8
Ratio of I. H. P. Efficiency to Ideal eff.	%	48.5
Ratio of B. H. P. Efficiency to Ideal eff.	%	38.3
HEAT BALANCE		
Heat Supplied,	B.T.U.	482,600
Heat Supplied	%	100
Heat Equivalent of I. H. P.	B.T.U.	104,000
Heat Equivalent of B. H. P.	%	21.3
Heat Rejected in Jacket Water	B.T.U.	129,400
Heat Rejected in Jacket Water	%	26.8
Heat Lost in Exhaust, Radiation, etc.,	B.T.U.	233,400
Heat Lost in Exhaust, Radiation, etc.,	%	519
Temperature of Air in Intake Pipe,	Deg.F.	97
Temperature of Gas in Intake Manifold,	Deg.F.	68


Efficiency Tests. O HP To Maximum HP
Curve I Gals Per HP Hour.
Curve II B.T.U. Per H.P. Hour.
I.
II
Gals. Per H.P. Hour.
Thousand B.T.U. Per H.P. Hour.
CURVE SHEET NO 3
Brake Horse Power.



Effeciency Tests O.H.P. To Maximum, H.P.
Curve I. Thermal Effeciency
Curve II. Mechanical Effeciency
I
II
Thermal Effeciency in Per Cent.
Mechanical Effeciency in Per Cent.
Brake Horse Power.
CURVE SHEET NO.4

TESTS FROM 0 TO MAX. H.P.



Sample Cards.
from.
I.H.C. Gasoline Engine.

0 to Maximum Brake Load Tests.

RUN M

Cyl. I.

Cyl. II.

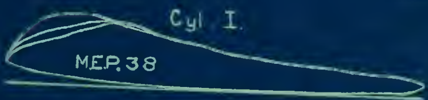
RUN I

Cyl. I.

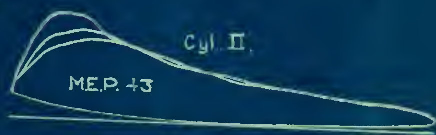
Cyl. II

RUN T

Cyl. I.

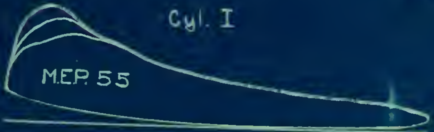


Cyl. II.

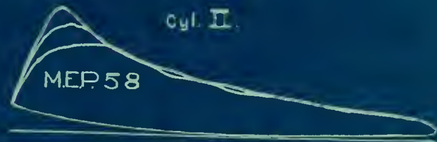


RUN H

Cyl. I

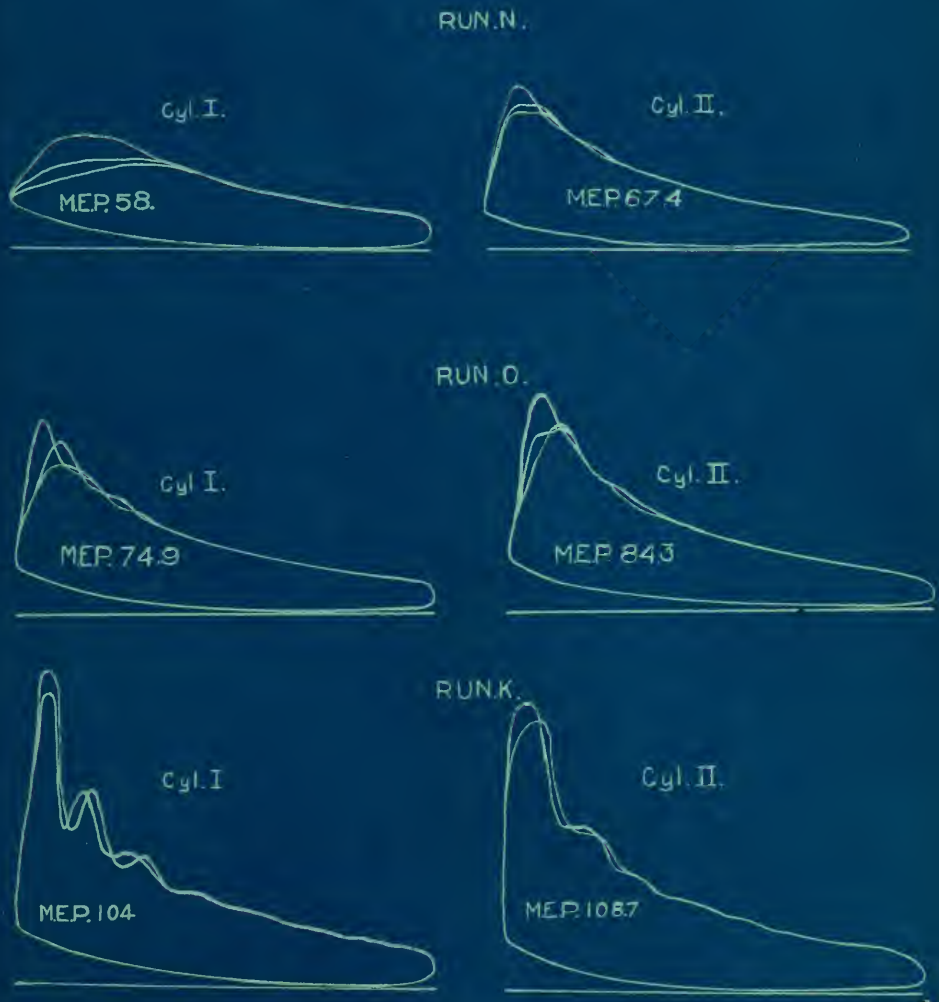


Cyl. II.



Sample Cards
from
I.H.C. Gasoline Engine.

0 to Maximum Brake Load Tests.

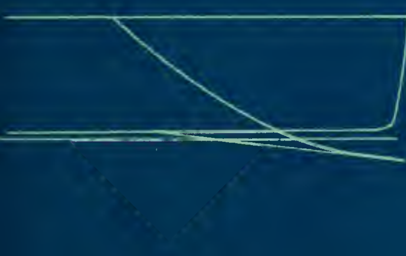


SAMPLE CARDS FROM
I.H.C GASOLINE ENGINE
TAKEN WITH LIGHT SPRING
AT 25 H.P.

CYLINDER I

CYLINDER II

CYLINDER I



CYLINDER II

TEST NO.II

EFFECT OF VARYING THE TEMPERATURE OF THE COOLING WATER

TEST OF I. H. C. GASOLINE ENGINE

EFFICIENCY AT DIFFERENT JACKET WATER TEMPERATURE. In the second series of tests the effect on the previous efficiencies of varying the temperature of the cooling water was determined. This was accomplished by throttling the amount of water passing through the jacket until the desired temperature was obtained. In order that any change in efficiency could not be charged to change in the viscosity of the lubricating oil, the inlet water was run in at the bottom of the cylinder. In this way the temperature of the greater part of the cylinder barrel was kept nearly constant throughout the tests; the temperature of the water around the cartridge chamber only being changed.

These tests were all run at the rated power, twenty-five horse power, and as will be seen in curve sheet No. 6, a marked increase in thermal efficiency is obtained as the jacket water temperature is increased. This increase is con-

TEST OF I. H. C. GASOLINE ENGINE

siderable, the thermal efficiency being 18% at a jacket water temperature of 65° F. and 20% at a jacket water temperature of 210° F. This is an increase in thermal efficiency of 11%. The gasoline consumption at 65° F. was 18.73 pounds and at 210° F. was 16.80, a decrease of about 11%. This is due to the increased temperature of the combustion chamber walls, which vaporizes the gasoline more rapidly, thus producing a quicker burning mixture and hence less gasoline for the same power as at low temperatures. It can be readily seen that the best results would therefore be obtained if the water could be evaporated out of the jacket as in a hopper cooled engine.

As will be seen on curve sheet No. 6, the mechanical efficiency rises as the water gets hotter up to 160° and then slowly begins to fall. This same phenomena is observed in the per cent of heat going into the cooling water as this rises steadily until 115° water is reached, when it falls away rapidly.

TEST OF I. H.C. GASOLINE ENGINE

On curve sheet No. 7 will be seen the results plotted in the form of B. T. U. per Horse Power per hour and gallons of gasoline per Horse Power per hour against the temperature of the jacket water. This shows that the B. T. U. used per Horse Power hour changes very materially with change of temperature of the water, to the greater saving in gasoline at the higher temperatures.

TEST OF I. H. C. GASOLINE ENGINE
Armour Institute of Technology

April 17, 1911.

Type: Victor Two Cylinder Vertical.

Fuel Used: Gasoline.

Builders Rating: 25 H. P. at 325 R.P.M.

Bore: 8". Stroke: 10". Clearance:31.5% piston displacement.

Brake Circumference, 33 ft. Indicator Used: Crosby.

Dead Weight of Arm, 22 lbs. Scale Spring: 160#.

Object of Test: Effect of Varying the Temperature of the Cooling Water.

RUN NO.		C
Duration of Test	hours	1
Revolutions per Minute		323.5
Net Brake Load	lbs.	77.3
Actual Brake Horse Power		25
DATA FROM CARDS		
a Maximum Pressure, lbs. per Sq. In.		210
b Compression Pressure, lbs. per Sq. In.		51
c Mean Effective Pressure,lbs.per Sq.In.Cyl. 1		68.6
" " " " " " " Cyl. 2		91.4
Indicated Horse Power		34.07
Frictional Horse Power		9.07
Mechanical Efficiency		73.4
Gasoline per Hour		18.73
Gallons per Horse Power Hour		.1247
Calorific Value of Gasoline per lb.		18,850
Jacket Water per Hour	lbs.	5043
Inlet Cooling Water	Deg.F.	42
Outlet Cooling Water	Deg.F.	65.5
Range of Temperature	Deg.F.	23.5

TEST OF I. H. C. GASOLINE ENGINE
Armour Institute of Technology

RUN NO.		C
Air in Room		70
Barometric Pressure	Ins.HG.	29.56
B. T. U. per I. H. P. per Hour		10,350
B. T. U. per B. H. P. per Hour		14,125
Thermal Efficiency per I. H. P.	%	24.6
Thermal Efficiency per B. H. P.	%	18
Ideal Thermal Efficiency	%	43.8
Ratio of I. H. P. Efficiency to Ideal eff.	%	56.1
Ratio of B. H. P. Efficiency to Ideal eff.	%	41
HEAT BALANCE		
Heat Supplied	B.T.U.	353,050
Heat Supplied	%	100
Heat Equivalent of I. H. P.	B.T.U.	86,000
Heat Equivalent of I. H. P.	%	24.6
Heat Rejected in Jacket Water	B.T.U.	118,500
Heat Rejected in Jacket Water	%	33.6
Heat Lost in Exhaust, Radiation, etc.,	B.T.U.	147,750
Heat Lost in Exhaust, Radiation, etc.,	%	41.8
Temperature of Air in Intake Pipe	Deg.F.	100
Temperature of Gas in Intake Manifold	Deg.F.	78
Injected Water		--
Ratio of Injected Water to Gasoline		--

TEST OF I. H. C. GASOLINE ENGINE
Armour Institute of Technology

April 25, 1911

Type: Victor Two Cylinder Vertical.
Fuel Used: Gasoline.

Builders Rating: 25 H. P. at 325 R.P.M.

Bore: 8". Stroke: 10". Clearance: 31.5% piston displacement

Brake Circumference, 33 ft. Indicator Used: Crosby.

Dead Weight of Arm, 22lbs. Scale Spring: 160#.

Object of Test: Effect of Varying the Temperature of the Cooling Water.

RUN NO.		S
Duration of Test	hours	1
Revolutions per Minute		330
Net Brake Load		77
Actual Brake Horse Power		25
DATA FROM CARDS		
a Maximum Pressure, lbs. per Sq. In.		225
b Compression Pressure, lbs. per Sq. In.		35.2
c Mean Effective Pressure, lbs. per Sq. In. Cyl. 1		77.2
" " " " " " " Cyl. 2		78.3
Indicated Horse Power		32.5
Frictional Horse Power		7.5
Mechanical Efficiency		77
Gasoline per Hour	lbs.	18.90
Gallons per Horse Power Hour		.1260
Calorific Value of Gasoline per lb.	B.T.U.	19,000
Jacket Water per Hour	lbs.	2308
Inlet Cooling Water	Deg.F.	46
Outlet Cooling Water	Deg.F.	94.7
Range of Temperature	Deg.F.	48.7

TEST OF I. H. C. GASOLINE ENGINE
Armour Institute of Technology

RUN NO.		S
Air in Room		70
Barometric Pressure	Ins.Hg.	29.56
B. T. U. per I. H. P. per Hour		11,400
B. T. U. per B. H. P. per Hour		14,370
Thermal Efficiency per I. H. P.	%	22.3
Thermal Efficiency per B. H. P.	%	17.7
Ideal Thermal Efficiency	%	43.8
Ratio of I. H. P. Efficiency to Ideal eff.	%	51
Ratio of B. H. P. Efficiency to Ideal eff.	%	40.3
HEAT BALANCE		
Heat Supplied	B.T.U.	359,000
Heat Supplied	%	100
Heat Equivalent of I. H. P.	B.T.U.	82,750
Heat Equivalent of I. H. P.	%	23.1
Heat Rejected in Jacket Water	B.T.U.	122,000
Heat Rejected in Jacket Water	%	34
Heat Lost in Exhaust, Radiation, etc.,	B.T.U.	154,250
Heat Lost in Exhaust, Radiation, etc.,	%	42.9
Temperature of Air in Intake Pipe	Deg.F.	100
Temperature of Gas in Intake Manifold	Deg.F.	78
Injected Water		--
Ratio of Injected Water to Gasoline		--

TEST OF I. H. C. GASOLINE ENGINE
Armour Institute of Technology

April 17, 1911.

Type: Victor Two Cylinder Vertical.
Fuel Used: Gasoline.

Builders Rating: 25 H. P. at 325 R.P.M.

Bore: 8". Stroke: 10". Clearance: 31.5% piston displacement.

Brake Circumference, 33 ft. Indicator Used: Crosby.

Dead Weight of Arm, 22 lbs. Scale Spring: 160#.

Object of Test: Effect of Varying the Temperature of the Cooling Water.

RUN NO.		D
Duration of Test	hours	1
Revolutions per Minute		323
Net Brake Load	lbs.	77.3
Actual Brake Horse Power		25
DATA FROM CARDS		
a Maximum Pressure, lbs. per Sq. In.		200
b Compression Pressure, lbs. per Sq. In.		55
c Mean Effective Pressure, lbs. per Sq. In. Cyl. 1		68.1
" " " " " " " Cyl. 2		88.1
Indicated Horse Power		33.55
Frictional Horse Power		8.55
Mechanical Efficiency		74.6
Gasoline Per Hour	lbs.	17.65
Gallons per Horse Power Hour		.1178
Calorific Value of Gasoline per lb.	B.T.U.	18,850
Jacket Water per Hour		2371
Inlet Cooling Water	Deg.F.	45
Outlet Cooling Water	Deg.F.	113.5
Range of Temperature	Deg.F.	68.5

TEST OF I. H. C. GASOLINE ENGINE
Armour Institute of Technology

RUN NO.		D
Air in Room	Deg.F.	70
Barometric Pressure	Ins.Hg.	29.55
B. T. U. per I. H. P. per Hour		9,950
B. T. U. per B. H. P. per Hour		13,320
Thermal Efficiency per I. H. P.	%	25.55
Thermal Efficiency per B. H. P.	%	19.1
Ideal Thermal Efficiency	%	43.8
Ratio of I. H. P. Efficiency to Ideal eff.	%	58.3
Ratio of B. H. P. Efficiency to Ideal eff.	%	43.6
HEAT BALANCE		
Heat Supplied	B.T.U.	333,400
Heat Supplied	%	100
Heat Equivalent of I. H. P.	B.T.U.	85,400
Heat Equivalent of I. H. P.	%	25.65
Heat Rejected in Jacket Water	B.T.U.	162,300
Heat Rejected in Jacket Water	%	48.70
Heat Lost in Exhaust, Radiation, etc.,	B.T.U.	85,700
Heat Lost in Exhaust, Radiation, etc.,	%	25.65
Temperature of Air in Intake Pipe	Deg.F.	100
Temperature of Gas in Intake Manifold	Deg.F.	78
Injected Water		--
Ratio of Injected Water to Gasoline		--

TEST OF I. H. C. GASOLINE ENGINE
Armour Institute of Technology

RUN NO.		L
Air in Room		70
Barometric Pressure	Ins.Hg.	29.56
B. T. U. per I. H. P. per Hour		10,360
B. T. U. per B. H. P. per Hour		13,070
Thermal Efficiency per I. H. P.	%	24.6
Thermal Efficiency per B. H. P.	%	19.55
Ideal Thermal Efficiency	%	43.8
Ratio of I. H. P. Efficiency to Ideal eff.	%	56.1
Ratio of B. H. P. Efficiency to Ideal eff.	%	44.6
HEAT BALANCE		
Heat Supplied	B.T.U.	327,000
Heat Supplied	%	100
Heat Equivalent of I. H. P.	B.T.U.	80,400
Heat Equivalent of I. H. P.	%	24.6
Heat Rejected in Jacket Water	B.T.U.	137,000
Heat Rejected in Jacket Water	%	41.8
Heat Lost in Exhaust, Radiation, etc.,	B.T.U.	109,600
Heat Lost in Exhaust, Radiation, etc.,	%	33.6
Temperature of Air in Intake Pipe	Deg.F.	78
Temperature of Gas in Intake Manifold	Deg.F.	100

MECHANICAL ENGINEERING LABORATORY
Armour Institute of Technology

April 20, 1911.

Type: Victor Two Cylinder Vertical.

Fuel Used: Gasoline.

Builders Rating: 25 H. P. at 325 R.P.M.

Bore: 8". Stroke: 10". Clearance: 31.5% piston displacement

Brake Circumference, 33 ft. Indicator Used: Crpsby.

Dead Weight of Arm, 22 lbs. Scale Spring: 160#.

Object of Test: Varying Temperature of Cooling Water.

RUN NO.		L
Duration of Test	hours	1
Revolutions per Minute		325
Net Brake Load	lbs.	77
Actual Brake Horse Power		25
DATA FROM CARDS		
a Maximum Pressure, lbs. per Sq. In.		175
b Compression Pressure, lbs. per Sq. In.		43
c Mean Effective Pressure, lbs. per Sq. In. Cyl. 1		74.56
" " " " " " " Cyl. 2		78.5
Indicated Horse Power		31.53
Frictional Horse Power		6.53
Mechanical Efficiency	lbs.	79.2
Gasoline per Hour	lbs.	17.20
Gallons per Horse Power Hour		.1147
Calorific Value of Gasoline per lb.	B.T.U.	19,000
Jacket Water per Hour		1260
Inlet Cooling Water	Deg.F.	47.5
Outlet Cooling Water	Deg.F.	156.0
Range of Temperature	Deg.F.	108.5

TEST OF I. H. C. GASOLINE ENGINE
Armour Institute of Technology

April 19, 1911.

Type: Victor Two Cylinder Vertical.
Fuel Used: Gasoline.

Builders Rating: 25 H. P. at 325 R.P.M.

Bore: 8". Stroke: 10". Clearance: 31.5% Piston Displacement

Brake Circumference, 33 ft. Indicator Used: Crosby.

Dead Weight of Arm, 22 lbs. Scale Spring: 160#.

Object of Test: Varying Temperature of Cooling Water.

RUN NO.		J
Duration of Test	hours	1
Revolutions per Minute		325
Net Brake Load	lbs.	77
Actual Brake Horse Power		25
DATA FROM CARDS		
a Maximum Pressure, lbs. per Sq. In.		225
b Compression Pressure, lbs. per Sq. In.		55
c Mean Effective Pressure, lbs. per Sq. In.	Cyl. 1	76.58
" " " " " " "	Cyl. 2	78.5
Indicated Horse Power		31.90
Frictional Horse Power		6.90
Mechanical Efficiency		78.4
Gasoline per Hour		17.35
Gallons per Horse Power Hour		.1156
Calorific Value of Gasoline Per lb.	B.T.U.	19,000
Jacket Water per Hour		842
Inlet Cooling Water	Deg.F.	50
Outlet Cooling Water	Deg.F.	189
Range Temperature	Deg.F.	139

TEST OF I. H. C. GASOLINE ENGINE
Armour Institute of Technology

RUN NO.		J
Air in Room		70
Barometric Pressure	Ins.Hg.	29.5
B. T. U. per I. H. P. per Hour		10,350
B. T. U. per B. H. P. per Hour		13,200
Thermal Efficiency per I. H. P.	%	24.6
Thermal Efficiency per B. H. P.	%	19.28
Ideal Thermal Efficiency	%	43.8
Ratio of I. H. P. Efficiency to Ideal eff.	%	56.1
Ratio of B. H. P. Efficiency to Ideal eff.	%	44.
HEAT BALANCE		
Heat Supplied	B.T.U.	330,000
Heat Supplied	%	100
Heat Equivalent of I. H. P.	B.T.U.	81,250
Heat Equivalent of I. H. P.	%	24.6
Heat Rejected in Jacket Water	B.T.U.	117,000
Heat Rejected in Jacket Water	%	35,500
Heat Lost in Exhaust, Radiation, etc.,	B.T.U.	131,750
Heat Lost in Exhaust, Radiation, etc.,	%	39.9
Temperature of Air in Intake Pipe	Deg.F.	100
Temperature of Gas in Intake Manifold	Deg.F.	78
Injected Water		--
Ratio of Injected Water		--

TEST OF I. H. C. GASOLINE ENGINE
Armour Institute of Technology

April 21, 1911.

Type: Victor Two Cylinder Vertical

Fuel Used: Gasoline.

Builders Rating: 25 H. P. at 325 R.P.M.

Bore: 8". Stroke:10". Clearance: 31.5% piston displacement

Brake Circumference. 33 ft. Indicator Used: Crosby.

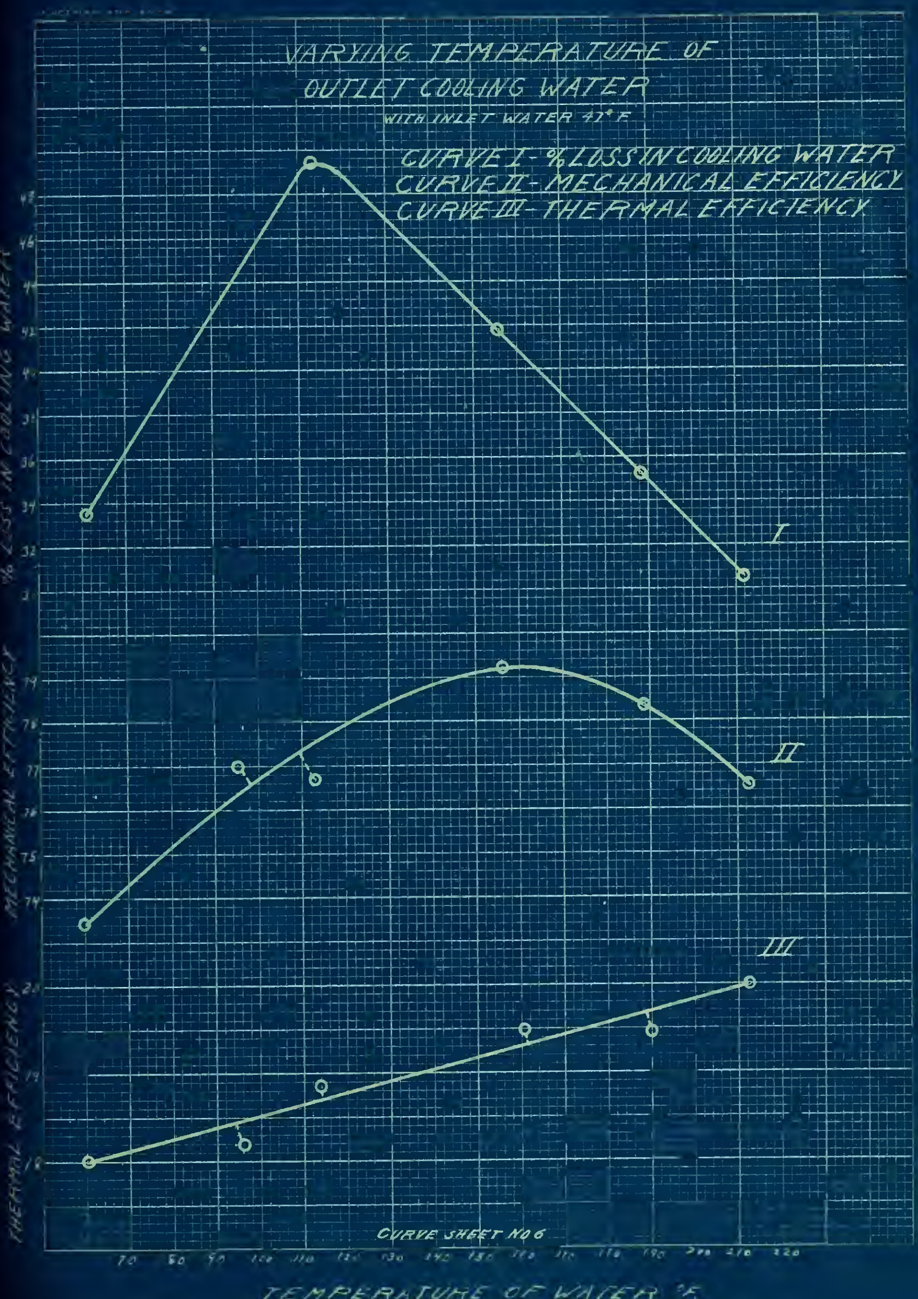
Dead Weight of Arm, 22 lbs. Scale Spring: 160#.

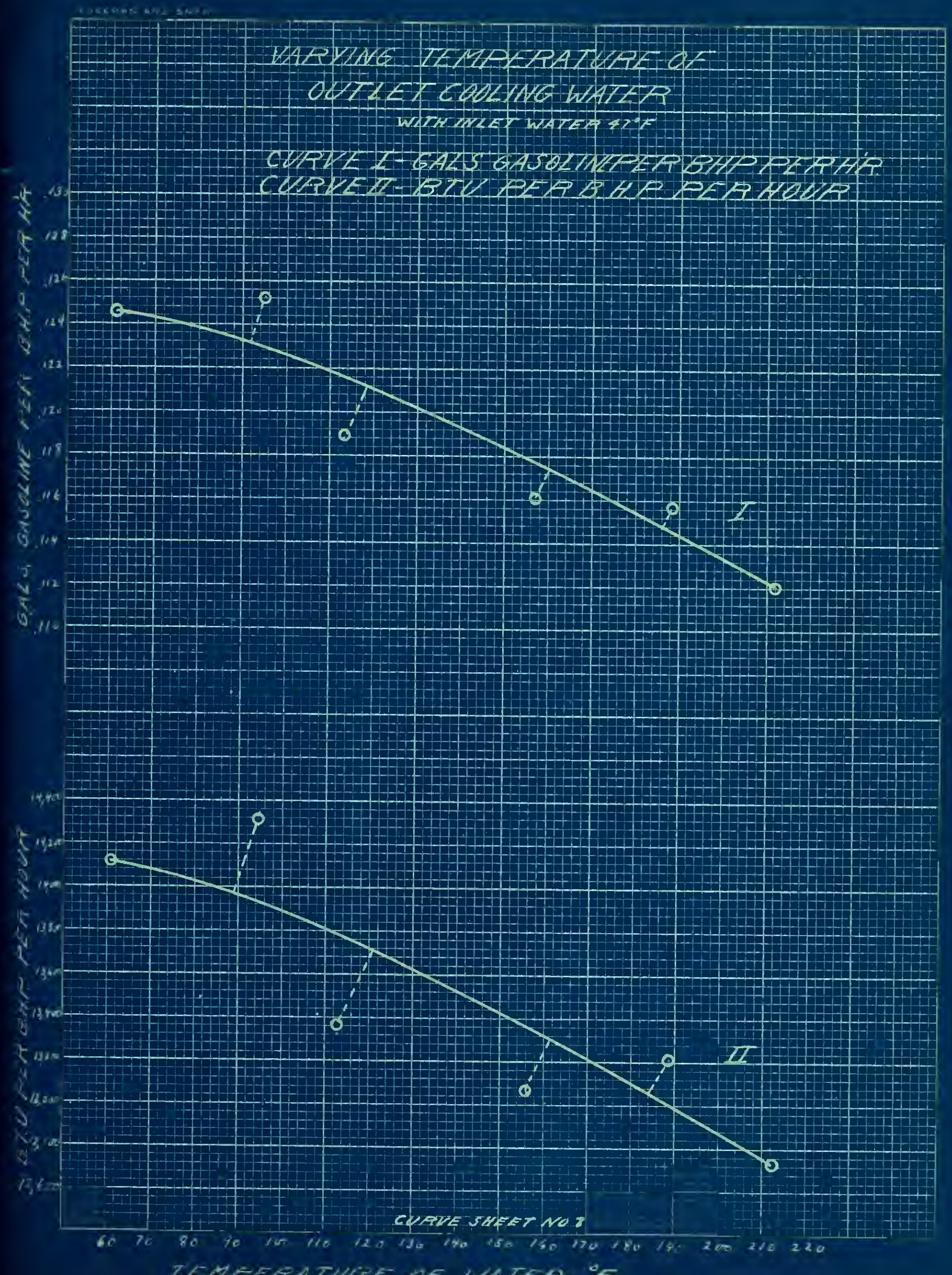
Object of Test: Varying Temperature of Jacket Water

RUN NO.		0
Duration of Test	hours	1
Revolutions per Minute		325
Net Brake Load	lbs.	77
Actual Brake Horse Power		25
DATA FROM CARDS		
a Maximum Pressure, lbs. per Sq. In.		204
b Compression Pressure, lbs. per Sq. In.		57.5
c Mean Effective Pressure, lbs. per Sq. In. Cyl. 1		74.9
" " " " " " " Cyl. 2		84.3
Indicated Horse Power		32.7
Frictional Horse Power		7.7
Mechanical Efficiency		76.6
Gasoline per Hour		16.8
Gallons per Horse Power Hour		.112
Calorific Value of Gasoline per lb.	B.T.U.	19,000
Jacket Water per Hour		610
Inlet Cooling Water	Deg.F.	52.40
Outlet Cooling Water	Deg.F.	211.25
Range of Temperature	Deg.F.	158.85

TEST OF I. H. C. GASOLINE ENGINE
Armour Institute of Technology

RUN NO.		0
Air in Room		75
Barometric Pressure	Ins Hg.	29.56
B. T. U. per I. H. P. per Hour		9,760
B. T. U. per B. H. P. per Hour		12,740
Thermal Efficiency per I. H. P.	%	26.1
Thermal Efficiency per B. H. P.	%	20
Ideal Thermal Efficiency	%	43.8
Ratio of I. H. P. Efficiency to Ideal eff.	%	59.5
Ratio of B. H. P. Efficiency to Ideal eff.	%	45.6
HEAT BALANCE		
Heat Supplied	B.T.U.	319,000
Heat Supplied	%	100
Heat Equivalent of I. H. P.	B.T.U.	83,400
Heat Equivalent of I. H. P.	%	26.1
Heat Rejected in Jacket Water	B.T.U.	96,800
Heat Rejected in Jacket Water	%	30.3
Heat Lost in Exhaust, Radiation, etc.,	B.T.U.	138,800
Heat Lost in Exhaust, Radiation, etc.,	%	43.6
Temperature of Air in Intake Pipe	Deg.F.	78
Temperature of Gas in Intake Manifold	Deg.F.	100


VARYING TEMPERATURE OF
OUTLET COOLING WATER
WITH INLET WATER 47° F
CURVE I - % LOSS IN COOLING WATER
CURVE II - MECHANICAL EFFICIENCY
CURVE III - THERMAL EFFICIENCY
% LOSS IN COOLING WATER
MECHANICAL EFFICIENCY
THERMAL EFFICIENCY
I
II
III
CURVE SHEET NO 6
TEMPERATURE OF WATER °F

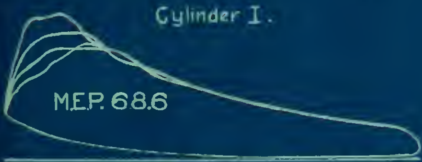


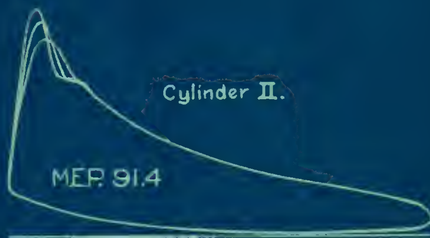
VARYING TEMPERATURE OF
OUTLET COOLING WATER
WITH INLET WATER 47°F
CURVE I - GALS GASOLINE PER BHP PER HR
CURVE II - BTU PER B.H.P. PER HOUR
GALS GASOLINE PER BHP PER HR
.130
.128
.126
.124
.122
.120
.118
.116
.114
.112
.110
I
B.T.U. PER BHP PER HOUR
14,400
14,200
14,000
13,800
13,600
13,400
13,200
13,000
12,800
12,600
II
CURVE SHEET NO 7
60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220
TEMPERATURE OF WATER °F

Sample Cards.
from
I.H.C. Gasoline Engine.

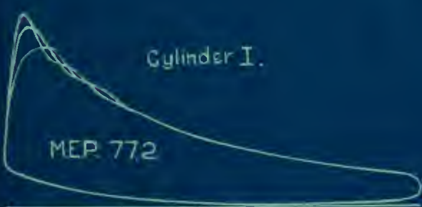
Cooling Water Temperatures.

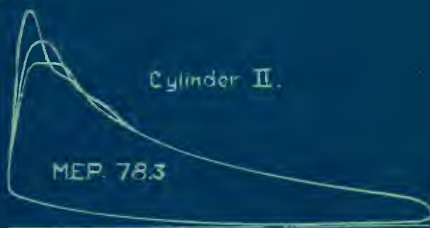
RUN C.



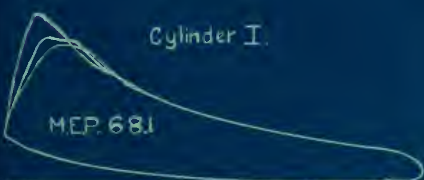


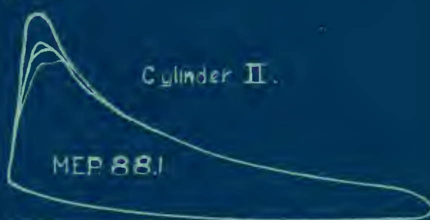
RUN S.





RUN D

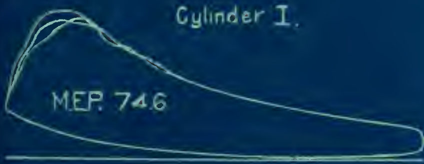


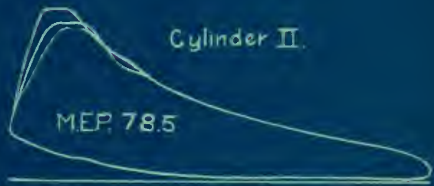


Sample Cards.
from
I.H.C. Gasoline Engine.

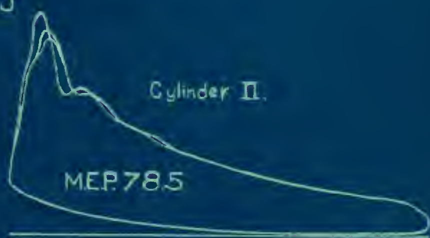
Cooling Water Temperatures.

RUN L

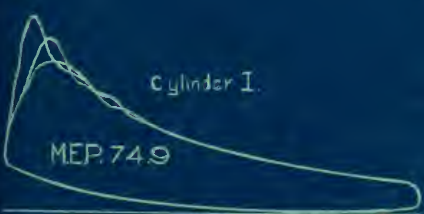


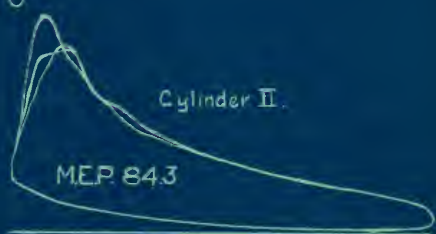


RUN J



RUN O





TEST NO. III

EFFICIENCY TEST WITH VARYING INLET AIR TEMPERATURES

TEST OF I. H. C. GASOLINE ENGINE

SPECIAL APPARATUS FOR TESTS ON HEATED AIR. In order to heat the air entering the carburettor, a seven inch stove pipe was placed around the exhaust manifold, leaving a clearance of one inch all around for the air to circulate in. This pipe was connected to the intake pipe by a flexible elbow. As far as possible from the intake entrance, vents were cut in the stove pipe to get as great a travel as possible. The intake pipe and also the intake manifold were fitted up with thermometers for determining the respective temperatures of the air before and after passing through the carburettor.

TEST OF I. H. C. GASOLINE ENGINE.

EFFICIENCY AT DIFFERENT TEMPERATURES OF INLET AIR. In the third series of tests the effect of heating the air going into the carburettor, by means of a jacket placed around the exhaust, was found. The results obtained were just the reverse of those obtained by the fourth series using injecting water. The thermal efficiency increased materially as the temperature of the entering air was raised, until at 290° it became 20.7% or .7% in excess of the best results obtained in any of the other tests. This may be seen in curve form on curve sheet No. 8, and on sheet No. 9 will be found the B. T. U. and gasoline consumption curves which of course slope down as the thermal efficiency goes up. The saving in gasoline with the hottest air, amounted to about 4% over that at normal conditions.

As in the case of heating the jacket water, this increase was obtained by the improvement in

the vaporizing of gasoline by the hot air, with the exception that the gasoline, in this case, was vaporized in the carburettor, while in the former case it was vaporized mostly in the cylinder itself.

As was expected, the engine "pounded" badly at normal load, caused by the quicker explosion when the spark was produced, the resulting enormous explosion pressure making it almost impossible to run the indicators. The spark was greatly retarded but this did not help much.

On account of this pressure the friction on the bearings caused the mechanical efficiency to drop as the temperature was raised, although not as much as might be expected. The curves showing this and also the explosion and compression pressures may be found on curve sheets No. 8 and No. 10.

TEST OF I. H. C. GASOLINE ENGINE
Armour Institute of Technology

April 27, 1911.

Type: Victor Two Cylinder Vertical.

Fuel Used: Gasoline.

Builders Rating: 25 H. P. at 325 R.P.M.

Bore: 8". Stroke: 10". Clearance: 31.5% Piston Displacement

Brake Circumference, 33 ft. Indicator Used: Crosby.

Dead Weight of Arm, 22 lbs. Scale Spring: 160#.

Object of Test: Efficiency Test with Varying Inlet Air Temperatures.

RUN NO.		Y
Duration of Test	hours	1
Revolutions per Minute		325
Net Brake Load	lbs.	77
Actual Brake Horse Power		25
DATA FROM CARDS		
a Maximum Pressure, lbs. per Sq. In.		243
b Compression Pressure, lbs. per Sq. In.		58.5
c Mean Effective Pressure, lbs. per Sq. In. Cyl. 1		72.65
" " " " " " " Cyl. 2		79.25
Indicated Horse Power		31.35
Frictional Horse Power		6.35
Mechanical Efficiency	%	79.8
Gasoline per Hour	lbs.	16.50
Gallons per Horse Power Hour		.110
Calorific Value of Gasoline per lb.,	B.T.U.	19,000
Jacket Water per Hour	lbs.	1544
Inlet Cooling Water	Deg.F.	47.75
Outlet Cooling Water	Deg.F.	124
Range of Temperature	Deg.F.	76.25

TEST OF I. H. C. GASOLINE ENGINE
Armour Institute of Technology

RUN NO.		Y
Air in Room		70
Barometric Pressure	Ins.Hg.	29.49
B. T. U. per I. H. P. per Hour		10,000
B. T. U. per B. H. P. per Hour		12,500
Thermal Efficiency per I. H. P.	%	25.45
Thermal Efficiency per B. H. P.	%	20.33
Ideal Thermal Efficiency	%	43.8
Ratio of I. H. P. Efficiency to Ideal eff.	%	58.2
Ratio of B. H. P. Efficiency to Ideal eff.	%	46.3
HEAT BALANCE		
Heat Supplied	B.T.U.	313,500
Heat Supplied	%	100
Heat Equivalent of I. H. P.	B.T.U.	79,800
Heat Equivalent of I. H. P.	%	25.45
Heat Rejected in Jacket Water	B.T.U.	117,700
Heat Rejected in Jacket Water	%	37.55
Heat Lost in Exhaust, Radiation, etc.,	B.T.U.	116,000
Heat Lost in Exhaust, Radiation, etc.,	%	37.
Temperature of Air in Intake Pipe	Deg.F.	219.5
Temperature of gas in Intake Manifold	Deg.F.	156.5

TEST OF I. H. C. GASOLINE ENGINE
Armour Institute of Technology

April 26, 1911.

Type: Victor Two Cylinder Vertical.

Fuel Used: Gasoline.

Builders Rating: 25 H. P. at 325 R.P.M.

Bore: 8". Stroke: 10". Clearance: 31.5% Piston Displacement.

Brake Circumference, 33 ft. Indicator Used: Crosby.

Dead Weight of Arm, 22 lbs. Scale Spring: 160#.

Object of Test: Efficiency Test with Varying Inlet Air Temperatures.

RUN NO.		U
Duration of Test	hours	1
Revolutions per Minute		325
Net Brake Load	lbs.	77
Actual Brake Horse Power		25
DATA FROM CARDS		
a Maximum Pressure, lbs. per Sq. In.		270
b Compression Pressure, lbs. per Sq. In.		61.5
c Mean Effective Pressure, lbs. per Sq. In. Cyl. 1		76
" " " " " " " Cyl. 2		84
Indicated Horse Power		32.95
Frictional Horse Power		7.95
Mechanical Efficiency		75.9
Gasoline per Hour	lbs.	16.60
Gallons per Horse Power Hour		.1105
Calorific Value of Gasoline per lb.	B.T.U.	19,000
Jacket Water per Hour	lbs.	1194
Inlet Cooling Water	Deg.F.	48
Outlet Cooling Water	Deg.F.	146.6
Range of Temperature	Deg.F.	98.6

TEST OF I. H. C. GASOLINE ENGINE
Armour Institute of Technology

RUN NO.		U
Air in Room		70
Barometric Pressure	Ins.Hg.	29.56
B. T. U. per I. H. P. per Hour		9,580
B. T. U. per B. H. P. per Hour		12,610
Thermal Efficiency per I. H. P.	%	26.8
Thermal Efficiency per B. H. P.	%	20.18
Ideal Thermal Efficiency	%	43.8
Ratio of I. H. P. Efficiency to Ideal eff.	%	61
Ratio of B. H. P. Efficiency to Ideal eff.	%	46.4
HEAT BALANCE		
Heat Supplied	B.T.U.	315,000
Heat Supplied	%	100
Heat Equivalent of I. H. P.	B.T.U.	84,000
Heat Equivalent of I. H. P.	%	26.8
Heat Rejected in Jacket Water	B.T.U.	118,000
Heat Rejected in Jacket Water	%	37.5
Heat Lost in Exhaust, Radiation, etc.,	B.T.U.	113,000
Heat Lost in Exhaust, Radiation, etc.,	%	35.7
Temperature of Air in Intake Pipe	Deg.F.	239
Temperature of Gas in Intake Manifold	Deg.F.	188.5

TEST OF I. H. C. GASOLINE ENGINE
Armour Institute of Technology

April 26, 1911.

Type: Victor Two Cylinder Vertical.

Fuel Used: Gasoline.

Builders Rating: 25 H. P. at 325 R.P.M.

Bore: 8". Stroke: 10". Clearance:31.5% Piston Displacement

Brake Circumference, 33 ft. Indicator Used: Crosby

Dead Weight of Arm, 22 lbs. Scale Spring: 160#.

Object of Test: Efficiency Test with Varying Inlet Temperatures.

RUN NO.		V
Duration of Test	hours	1
Revolutions per Minute		321
Net Brake Load	lbs.	78
Actual Brake Horse Power		25
DATA FROM CARDS		
a Maximum Pressure, lbs. per Sq. In.		
b Compression Pressure, lbs. per Sq. In.		
c Mean Effective Pressure, lbs. per Sq. In. Cyl. 1		
" " " " " " " Cyl. 2		
Indicated Horse Power		33.1
Frictional Horse Power		8.1
Mechanical Efficiency		75.5
Gasoline per Hour	lbs.	16.20
Gallons per Horse Power Hour		.108
Calorific Value of Gasoline per lb.	B.T.U.	19,000
Jacket Water per Hour	lbs.	1526
Inlet Cooling Water	Deg.F.	48
Outlet Cooling Water	Deg.F.	142
Range of Temperature	Deg.F.	94

TEST OF I. H. C. GASOLINE ENGINE
Armour Institute of Technology

RUN NO.		V
Air in Room		70
Barometric Pressure	Ins.Hg.	29.56
B. T. U. per I. H. P. per Hour		9,330
B. T. U. per B. H. P. per Hour		12,320
Thermal Efficiency per I. H. P.	%	27.3
Thermal Efficiency per B. H. P.	%	20.7
Ideal Thermal Efficiency	%	43.8
Ratio of I. H. P. Efficiency to Ideal eff.	%	62.2
Ratio of B. H. P. Efficiency to Ideal eff.	%	47.2
HEAT BALANCE		
Heat Supplied	B.T.U.	308,000
Heat Supplied,	%	100
Heat Equivalent of I. H. P.	B.T.U.	84,200
Heat Equivalent of I. H. P.	%	27.4
Heat Rejected in Jacket Water	B.T.U.	143,250
Heat Rejected in Jacket Water	%	46.5
Heat Lost in Exhaust, Radiation, etc.,	B.T.U.	81,550
Heat Lost in Exhaust, Radiation, etc.,	%	26.1
Temperatue of Air in Intake Pipe	Deg.F.	284
Temperature of Gas in Ibtake Manifold	Deg.F.	220

TEST OF I. H. C. GASOLINE ENGINE
Armour Institute of Technology

April 17, 1911.

Type: Victor Two Cylinder Vertical.

Fuel Used: Gasoline.

Builders Rating: 25 H. P. at 325 R.P.M.

Bore: 8". Stroke: 10". Clearance; 31.5% Piston Displacement.

Brake Circumference, 33 ft. Indicator Used: Crosby.

Dead Weight of Arm, 22 lbs. Scale Spring: 160#.

Object of Test: Effect of Varying the Temperature of the Cooling Water.

RUN NO.		D
Duration of Test	hours	1
Revolutions per Minute,		323
Net Brake Load	lbs.	77.3
Actual Brake Horse Power		25
DATA FROM CARDS		
a Maximum Pressure, lbs. per Sq. In.		200
b Compression Pressure, lbs. per Sq. In.		55
c Mean Effective Pressure, lbs. per Sq. In. Cyl. 1		68.1
" " " " " " " Cyl. 2		88.1
Indicated Horse Power		33.55
Frictional Horse Power		8.55
Mechanical Efficiency		74.6
Gasoline Per Hour	lbs.	17.65
Gallons per Horse Power Hour		.1178
Calorific Value of Gasoline per lb.	B.T.U.	18,850
Jacket Water per Hour		2371
Inlet Cooling Water	Deg.F.	45
Outlet Cooling Water	Deg.F.	113.5
Range of Temperature	Deg.F.	68.5

TEST OF I. H. C. GASOLINE ENGINE
Armour Institute of Technology.

RUN NO.		D
Air in Room	Deg.F.	70
Barometric Pressure	Ins. Hg.	29.55
B. T. U. per I. H. P. per Hour		9,950
B. T. U. per B. H. P. per Hour		13,320
Thermal Efficiency per I. H. P.	%	25.55
Thermal Efficiency per B. H. P.	%	19.1
Ideal Thermal Efficiency	%	43.8
Ratio of I. H. P. Effieiency to Ideal eff.	%	58.3
Ratio of B. H. P. Efficiency to Ideal eff.	%	43.6
HEAT BALANCE		
Heat Supplied	B.T.U.	333,400
Heat Supplied	%	100
Heat Equivalent of I. H. P.	B.T.U.	85,400
Heat Equivalent of I. H. P.	%	25.65
Heat Rejected in Jacket Water	B.T.U.	162,300
Heat Rejected in Jacket Water,	%	48.70
Heat Lost in Exhaust, Radiation, etc.,	B.T.U.	85,700
Heat Lost in Exhaust, Radiation, etc.,	%	25.65
Temperature of Air in Intake Pipe	Deg.F.	100
Temperature of Gas In Intake Manifold	Deg.F.	78

TEST OF I. H. C. GASOLINE ENGINE
Armour Institute of Technology

April 18, 1911

Type: Victor Two Cylinder Vertical.
Fuel Used: Gasoline.
Builders Rating: 25 H. P. at 325 R.P.M.

Bore: 8". Stroke: 10". Clearance; 31.5% Piston Displacement

Brake Circumference, 33ft. Indicator Used: Crosby.

Dead Weight of Arm, 22 lbs. Scale Spring: 160#.

Object of Test: Efficiency Tests at Various Brake Loads.

RUN NO.		H
Duration of Test	hours	1
Revolutions per Minute		332
Net Brake Load	lbs.	45.2
Actual Brake Horse Power		15
DATA FROM CARDS		
a Maximum Pressure, lbs. per Sq. In.		108.
b Compression Pressure, lbs. per Sq. In.		37.5
c Mean Effective Pressure, lbs. per Sq. In. Cyl. 1		54.86
" " " " " " " Cyl. 2		58.12
Indicated Horse Power		23.74
Frictional Horse Power		8.74
Mechanical Efficiency	%	63.2
Gasoline per Hour	lbs.	14.00
Gallons per Horse Power Hour		.1555
Calorific Value of Gasoline per lb.	B.T.U.	18,880
Jacket Water per Hour		1524
Inlet Cooling Water	Deg.F.	45
Outlet Cooling Water	Deg.F.	109.6
Range of Temperature	Deg.F.	64.6

TEST OF I. H. C. GASOLINE ENGINE
Armour Institute of Technology

RUN NO.		H
Air in Room		70
Barometric Pressure	Ins.Hg.	29.52
B. T. U. per I. H. P. per Hour		11.110
B. T. U. per B. H. P. per Hour		17,600
Thermal Efficiency per I. H. P.	%	22.9
Thermal Efficiency per B. H. P.	%	14.45
Ideal Thermal Efficiency	%	43.8
Ratio of I. H. P. Efficiency to Ideal eff.	%	52.2
Ratio of B. H. P. Efficiency to Ideal eff.	%	33
HEAT BALANCE		
Heat Supplied	B.T.U.	264,000
Heat Supplied	%	100
Heat Equivalent of I. H. P.	B.T.U.	60,400
Heat Equivalent of I. H. P.	%	22.9
Heat Rejected in Jacket Water	B.T.U.	98,500
Heat Rejected in Jacket Water	%	37.3
Heat Lost in Exhaust, Radiation, etc.,	B.T.U.	105,000
Heat Lost in Exhaust, Radiation, etc.,	%	39.8
Temperature of Air in Intake Pipe	Deg.F.	104
Temperature of Gas in Intake Manifold	Deg.F.	89

TEST OF I. H. C. GASOLINE ENGINE
Armour Institute of Technology

April 27, 1911.

Type: Victor Two Cylinder Vertical.

Fuel Used: Gasoline.

Builders Rating: 25 H. P. at 325 R. P. M.

Bore: 8". Stroke: 10". Clearance: 31.5% Piston Displacement

Brake Circumference, 33 ft. Indicator Used: Crosby.

Dead Weight of Arm, 22 lbs. Scale Spring: 160#.

Object of Test: Efficiency Test with Varying Inlet Air Temperatures.

RUN NO.		X
Duration of Test	hours	1
Revolutions per Minute		330
Net Brake Load	lbs.	66
Actual Brake Horse Power		15
DATA FROM CARDS		
a Maximum Pressure, lbs. per Sq. In.		131
b Compression Pressure, lbs. per Sq. In.		32
c Mean Effective Pressure, lbs. per Sq. In. Cyl. 1		49.4
" " " " " " " Cyl. 2		54.7
Indicated Horse Power		22
Frictional Horse Power		7
Mechanical Efficiency		68.
Gasoline per Hour	lbs.	14.25
Gallons per Horse Power Hour		.1585
Calorific Value of Gasoline per lb.	B.T.U.	19,000
Jacket Water per Hour	lbs.	1806
Inlet Cooling Water	Deg.F.	46
Outlet Cooling Water	Deg.F.	97
Range of Temperature	Deg.F.	51

TEST OF I. H. C. GASOLINE ENGINE
Armour Institute of Technology

RUN NO.		X
Air in Room		70
Barometric Pressure	Ins.Hg.	29.51
B. T. U. per I. H. P. per Hour		12,300
B. T. U. per B. H. P. per Hour		18,050
Thermal Efficiency per I. H. P.	%	20.7
Thermal Efficiency per B. H. P.	%	14.1
Ideal Thermal Efficiency	%	43.8
Ratio of I. H. P. Efficiency to Ideal eff.	%	47.2
Ratio of B. H. P. Efficiency to Ideal eff.	%	32.1
HEAT BALANCE		
Heat Supplied	B.T.U.	271,000
Heat Supplied	%	100
Heat Equivalent of I. H. P.	B.T.U.	56,000
Heat Equivalent of I. H. P.	%	20.7
Heat Rejected in Jacket Water	B.T.U.	92,200
Heat Rejected in Jacket Water	%	34
Heat Lost in Exhaust, Radiation, etc.,	B.T.U.	122,800
Heat Lost in Exhaust, Radiation, etc.,	%	45.3
Temperature of Air in Intake Pipe	Deg.F.	200
Temperature of Gas in Intake Manifold	Deg.F.	153

TEST OF I. H. C. GASOLINE ENGINE
Armour Institute of Technology

April 26, 1911.

Type: Victor Two Cylinder Vertical.

Fuel Used: Gasoline.

Builders Rating: 25 H. P. at 325 R.P.M.

Bore: 8". Stroke: 10". Clearance: 31.5% Piston Displacement.

Brake Circumference, 33 ft. Indicator Used: Crosby.

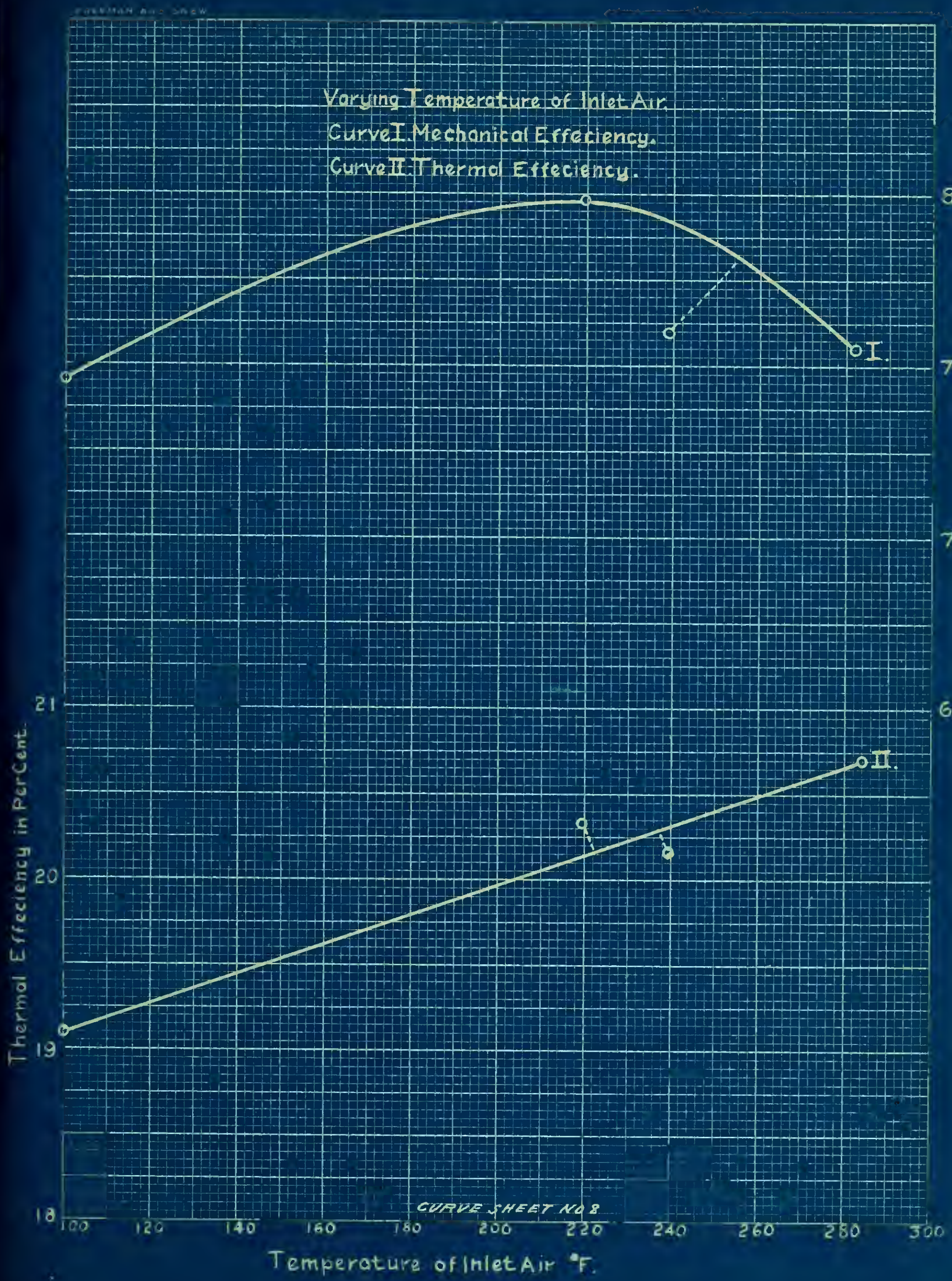
Dead Weight of Arm, 22lbs. Scale Spring: 160#.

Object of Test: Effieiency Test with Varying Inlet Air Temperatures.

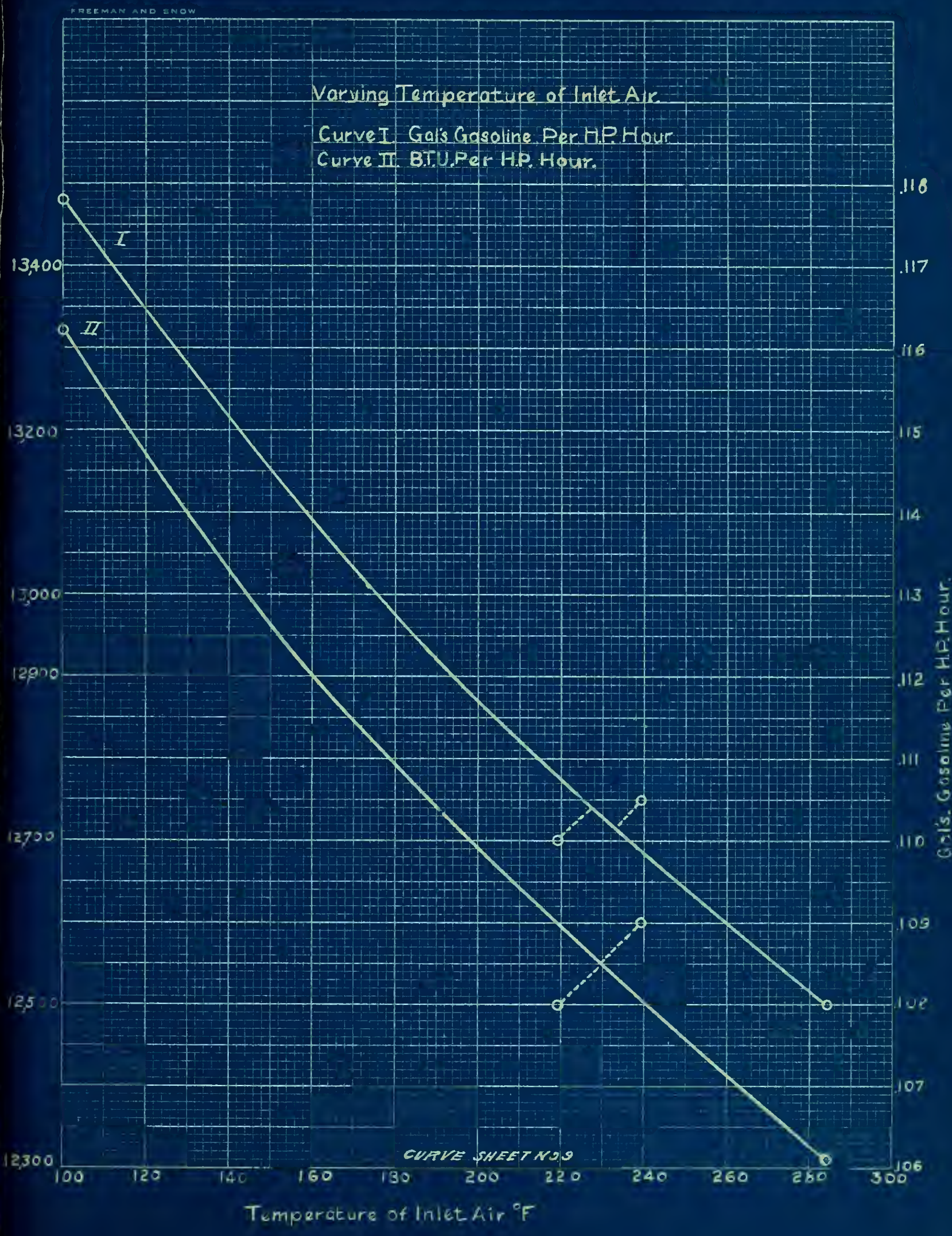
RUN NO.		W
Duration of Test	hours	1
Revolutions per Minute		330
Net Brake Load	lbs.	66
Actual Brake Horse Power		15
DATA FROM CARDS		
a Maximum Pressure, lbs. per Sq. In.		126
b Compression Pressure, lbs. per Sq. In.		54.5
c Mean Effective Pressure,lbs.per Sq.In?Cyl. 1		51
" " " " " " " Cyl. 2		50
Indicated Horse Power		21.1
Frictional Horse Power		6.1
Mechanical Efficiency		70.7
Gasoline per Hour	lbs.	1340
Gallons per Horse Power Hour		.149
Calorific Value of Gasoline per lb.	B.T.U.	19,000
Jacket Water per Hour	lbs.	1212
Inlet Cooling Water	Deg.F.	48
Outlet Cooling Water	Deg.F.	115
Range of Temperature	Deg.F.	67

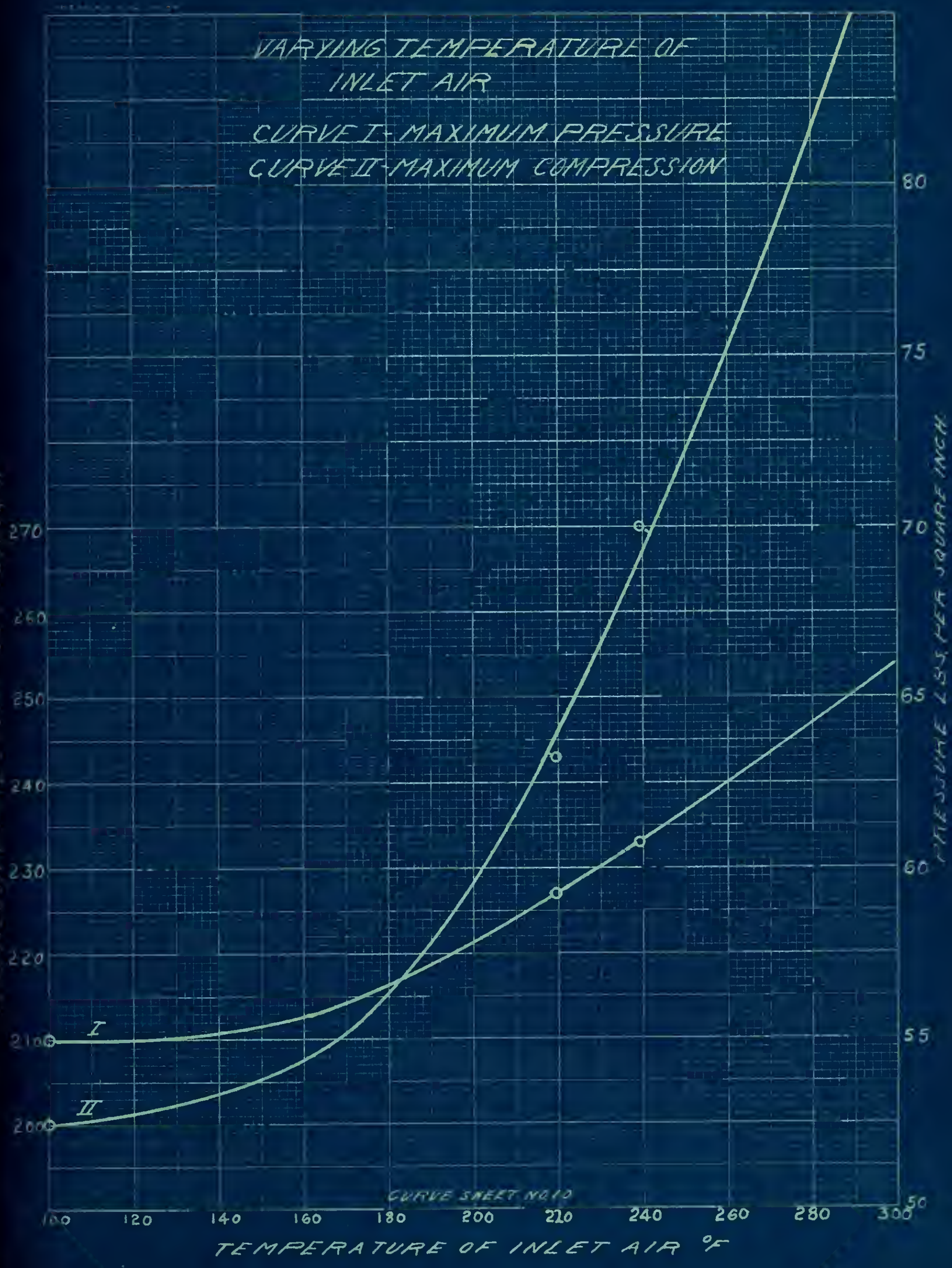
TEST OF I. H. C. GASOLINE ENGINE
Armour Institute of Technology

RUN NO.		W
Air in Room		70
Barometric Pressure	Ins.Hg.	29.56
B. T. U. per I. H. P. per Hour		12,080
B. T. U. per B. H. P. per Hour		16,950
Thermal Efficiency per I. H. P.	%	21.1
Thermal Efficiency per B. H. P.	%	15
Ideal Thermal Efficiency	%	43.8
Ratio of I. H. P. Efficiency to Ideal eff.	%	48.2
Ratio of B. H. P. Efficiency to Ideal eff.	%	39.2
HEAT BALANCE		
Heat Supplied	B.T.U.	254,500
Heat Supplied	%	100
Heat Equivalent of I. H. P.	B.T.U.	53,700
Heat Equivalent of I. H. P.	%	21.1
Heat Rejected in Jacket Water	B.T.U.	81,200
Heat Rejected in Jacket Water	%	32
Heat Lost in Exhaust, Radiation, etc.,	B.T.U.	119,600
Heat Lost in Exhaust, Radiation, etc.,	%	46.9
Temperature of Air in Intake Pipe,	Deg.F.	288
Temperature of Gas in Intake Manifold	Deg.F.	230



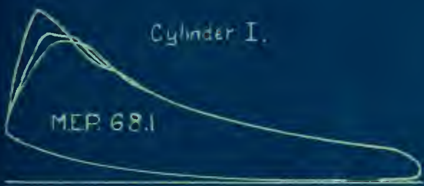
Varying Temperature of Inlet Air.
Curve I. Mechanical Effeciency.
Curve II. Thermal Effeciency.
I.
II.
80
75
70
65
21
20
19
18
100
120
140
160
180
200
220
240
260
280
300
Mechanical Effeciency in Per Cent.
Thermal Effeciency in Per Cent.
CURVE SHEET No 8
Temperature of Inlet Air °F.

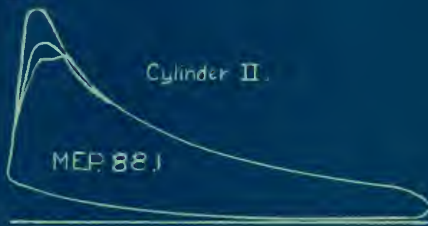

FREEMAN AND SNOW
Varying Temperature of Inlet Air.
Curve I. Gal's Gasoline Per H.P. Hour
Curve II. B.T.U. Per H.P. Hour.
I
II
13,400
13,200
13,000
12,900
12,700
12,500
12,300
.118
.117
.116
.115
.114
.113
.112
.111
.110
.109
.108
.107
.106
Gal's. Gasoline Per H.P. Hour.
CURVE SHEET NO 9
100
120
140
160
180
200
220
240
260
280
300
Temperature of Inlet Air °F


VARYING TEMPERATURE OF INLET AIR
CURVE I - MAXIMUM PRESSURE
CURVE II - MAXIMUM COMPRESSION
I
II
270
260
250
240
230
220
210
200
80
75
70
65
60
55
50
100
120
140
160
180
200
210
240
260
280
300
PRESSURE LBS PER SQUARE INCH
CURVE SHEET NO 10
TEMPERATURE OF INLET AIR °F

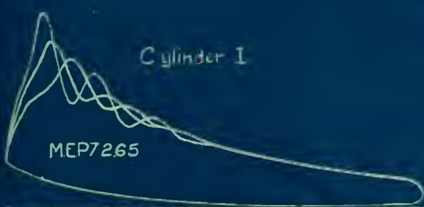
Sample Cards.
from
I.H.C. Gasoline Engine.
25 H.P.
Varying Temperature. of Inlet Air.

RUN D

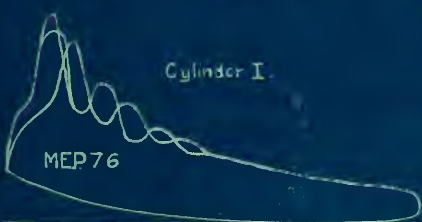


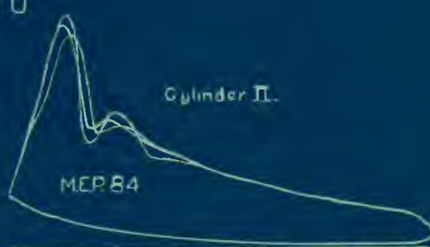


RUN Y



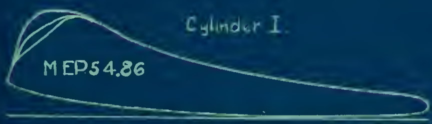
RUN U

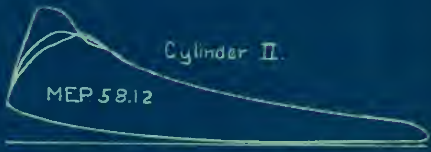




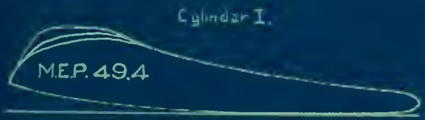
Sample Cards.
from
I.H.C. Gasoline Engine.
15 H.P.
Varying Temperature. of Inlet Air.

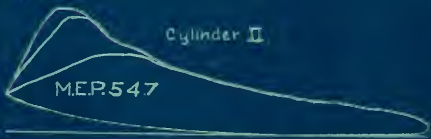
RUN H.



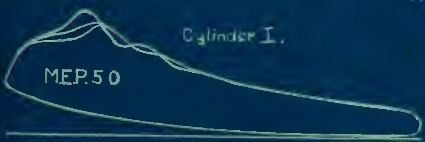


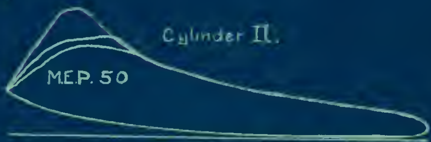
RUN X.





RUN W.





TEST NO. IV

EFFECT OF WATER INJECTION ON EFFICIENCY OF ENGINE

TEST OF I. H. C. GASOLINE ENGINE

SPECIAL APPARATUS FOR WATER INJECTION TESTS. For the purpose of injecting water into the cylinders, we bored two nine-sixteenth inch holes in the top of the intake manifold, one near each of the cylinders. Into these we screwed gravity feed, one-half pint, sight feed oil cups which were filled with water. With these we could regulate the supply into either cylinder at will. To keep these cups full of water, and also to obtain the amount used, we suspended a spring balance from a hook above the engine, and onto this we hooked a one gallon pail. At the bottom of the pail a one-quarter inch copper tube was put through and this was connected by means of a rubber tube to a brass manifold which was connected to both of the cups. The rubber tubing was provided with a pinch cock so that the supply could be regulated at will.

TEST OF I. H. C. GASOLINE ENGINE

EFFECT OF INJECTING WATER INTO THE CYLINDERS. The fourth series of tests were made with water injected into the cylinders of the engine. At high loads this eliminated the "pounding" of the engine almost entirely, and made it run very smoothly and quietly.

The injection of water into the cylinders greatly reduces the temperature of compression, the heat being taken up in converting a part of the water into steam. On the explosion stroke a portion of the heat is taken up in vaporizing the water. This causes the explosion to be more gradual and to be extended over a greater period of time. The maximum pressure is thus much lower than normal and occurs much later in the explosion stroke. For this reason the pressure on the bearings is reduced and a higher mechanical efficiency obtained. In one run the mechanical efficiency was as high as 84.3% as against 80% under normal conditions. The greatest overload that could be carried under normal conditions was 25% while when water was injected into the cylinders an overload of 40% was easily handled.

TEST OF I. H. C. GASOLINE ENGINE.

The great drawback to the injection of water into the cylinders is the decrease in thermal efficiency, it being only 17.6% as compared with 20% under normal conditions. This can be accounted for in that more power is taken up in vaporizing the water than is returned by it in the form of steam pressure. Also since the maximum pressure occurs later the heat lost to the exhaust is probably greatly increased. The consumption of gasoline was found to be about 10% greater when the water was injected. The proper ratio of water injected to fuel used was found to be about one to three, or one to two, by weight.

MECHANICAL ENGINEERING LABORATORY
Armour Institute of Technology.

Date, April 24, 1911.

Test of: International Harvester Company Gasoline Engine.

Type: Victor Two Cylinder Vertical.

Fuel Used: Gasoline.

Builders Rating: 25 H. P. at 325 R.P.M.

Bore: 8". Stroke: 10". Clearance: 31.5% piston displacement.

Brake circumference, 33 ft. Indicator Used: Crosby.

Dead Weight of Arm, 22 lbs. Scale Spring: 160#.

Object of Test: Effect of Water Injection on Effieiency of Engine.

RUN NO.		R
Duration of Test	hours	1
Revolutions per Minute		337
Net Brake Load	lbs.	44.8
Actual Brake Horse Power		15
DATA FROM CARDS		
a Maximum Pressure, lbs. per Sq. In.		114
b Compression Pressure, lbs. per Sq. In.		37.5
c Mean Effective Pressure, lbs. per Sq. In.	Cyl.1	50.4
" " " " " "	" Cyl.2	50.6
Indicated Horse Power		21.6
Frictional Horse Power		6.6
Mechanical Efficiency	%	68.8
Gasoline per Hour	lbs.	16.90
Gallons per H. P. Hour		.1880
Calorific Value of Gasoline per lb.	B.T.U.	19,000
Jacket Water per Hour	lbs.	1250
Inlet Cooling Water	Deg. F.	49
Outlet Cooling Water	Deg. F.	125
Range of Temperature	Deg. F.	76

MECHANICAL ENGINEERING LABORATORY
Armour Institute of Technology

RUN NO.		R
Air in Room		70
Barometric Pressure	Ins. Hg.	29.56
B. T. U. per I H. P. per Hour		14,850
B. T. U. per B. H. P. per Hour		21,400
Thermo eff. per I. H. P.	%	17.2
Thermo eff. per B. H. P.	%	11.9
Ideal Thermal Efficiency	%	43.8
Ratio of I. H. P. Efficiency to Ideal eff.	%	39.2
Ratio of B. H. P. Efficiency to Ideal eff.	%	27.1
HEAT BALANCE		
Heat Supplied,	B.T.U.	321,000
Heat Supplied	%	100
Heat Equivalent of I. H. P.	B.T.U.	55,000
Heat Equivalent of I. H. P.	%	17.2
Heat Rejected in Jacket Water	B.T.U.	95,000
Heat Rejected in Jacket Water	%	29.6
Heat Lost in Exhaust, Radiation, etc.,	B.T.U.	171,000
Heat Lost in Exhaust, Radiation, etc.,	%	53.2
Temperatureof Air in Intake Pipe	Deg.F.	104
Temperature of Gas in Intake Manifold	Deg.F.	89
Injected Water	pounds.	3.5
Ratio of Injected Water to Gasoline	%	20.7

TEST OF I. H. C. GASOLINE ENGINE
Armour Institute of Technology

April 24, 1911

Type: Victor Two Cylinder Vertical.
Fuel Used: Gasoline.
Builders Rating: 25 H. P. at 325 R.P.M.

Bore: 8". Stroke: 10". Clearance: 31.5% Piston Displacement.

Brake Circumference, 33 ft. Indicator Used: Crosby.

Dead Weight of Arm, 22 lbs. Scale Spring: 160#.

Object of Test: Effect of Water Injection on Efficiency of Engine

RUN NO.		P
Duration of Test	hours	1
Revolutions per Minute		325
Net Brake Load	lbs.	77
Actual Brake Horse Power		25
DATA FROM CARDS		
a Maximum Pressure, lbs. per Sq. In.		165
b Compression Pressure, lbs. per Sq.In.		43.3
c Mean Effective Pressure, lbs. per Sq.In. Cyl. 1		73.8
" " " " " " " Cyl. 2		83
Indicated Horse Power		32.30
Frictional Horse Power		7.30
Mechanical Efficiency	%	77.4
Gasoline per Hour	lbs.	18.30
Calorific Value of Gasoline per lb.	B.T.U.	19,000
Gallons per H. P. Hour,		.1218
Jacket Water per Hour	lbs.	1394
Inlet Cooling Water,	Deg.F.	47
Outlet Cooling Water	Deg.F.	129
Range of Temperature	Deg.F.	82

TEST OF I. H. C. GASOLINE ENGINE
Armour Institute of Technology

RUN NO.		P
Air in Room		70
Barometric Pressure	InssHg.	29.56
B. T. U. per I. H. P. per Hour		10,770
B. T. U. per B. H. P. per Hour		13,900
Thermal Efficiency per I. H. P.	%	23.7
Thermal Efficiency per B. H. P.	%	18.3
Ideal Thermal Efficiency	%	43.8
Ratio of I. H. P. Efficiency to Ideal eff.	%	54
Ratio of B. H. P. Efficiency to Ideal eff.	%	41
HEAT BALANCE		
Heat Supplied	B.T.U.	348,000
Heat Supplied	%	100
Heat Equivalent of I. H. P.	B.T.U.	82,200
Heat Equivalent of I. H. P.	%	23.7
Heat Rejected in Jacket Water	B.T.U%	114,300
Heat Rejected in Jacket Water	%	32.9
Heat Lost in Exhaust, Radiation, etc.,	B.T.U.	151,500
Heat Lost in Exhaust, Radiation, etc.,	%	43.4
Temperature of Air in Intake Pipe	Deg.F.	100
Temperature of Gas in Intake Manifold	Deg.F.	78
Injected Water	pounds.	7
Ratio of Injected Water to Gasoline	%	38.2

TEST OF I. H. C. GASOLINE ENGINE
Armour Institute of Technology

April 24, 1911

Type: Victor Two Cylinder Vertical.

Fuel Used: Gasoline

Builders Rating: 25 H. P. at 325 R.P.M.

Bore: 8". Stroke: 10". Clearance: 31.5% Piston Displacement.

Brake Circumference, 33 ft. Indicator Used: Crosby.

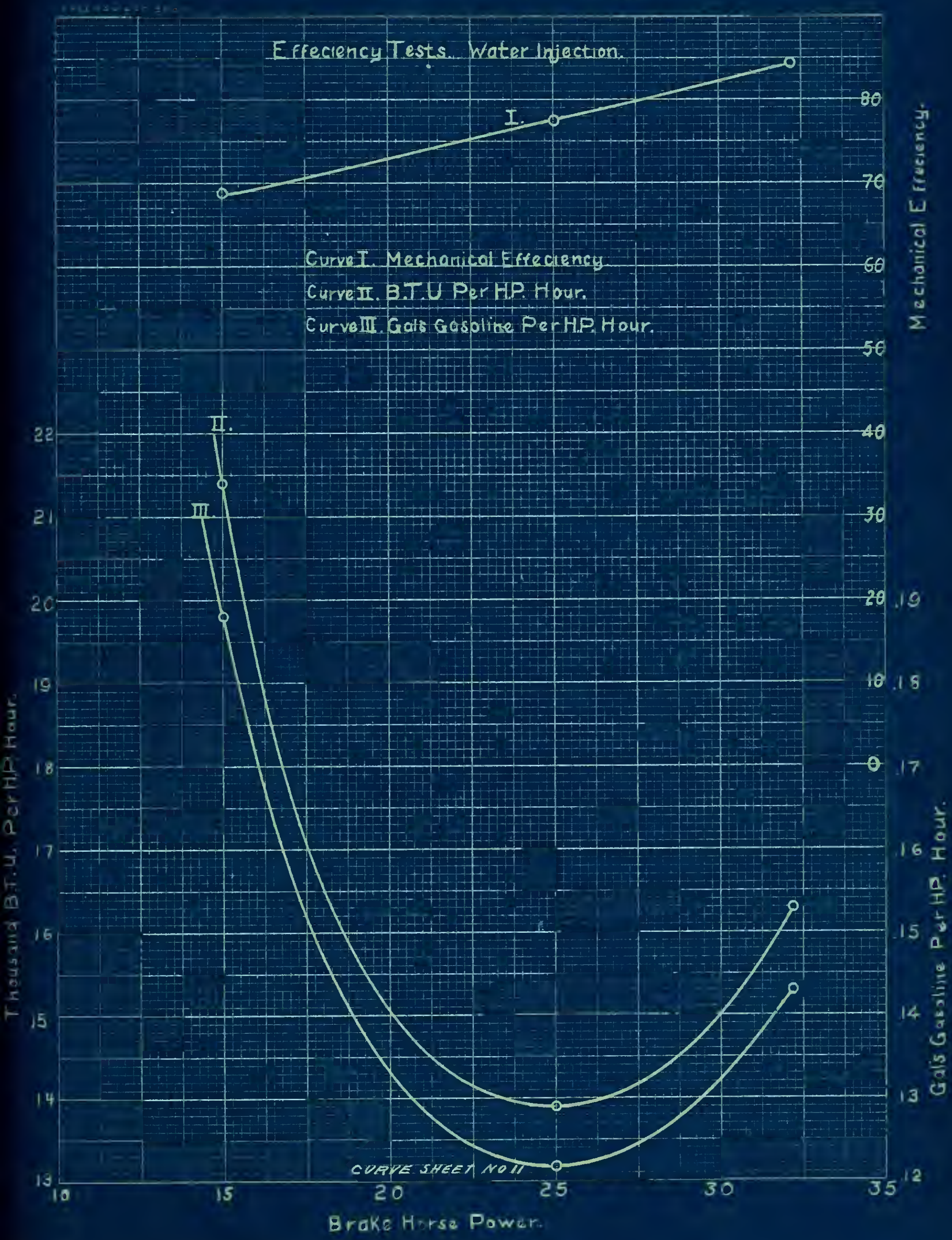
Dead Weight of Arm, 22 lbs. Scale Spring: 160#.

Object of Test: Effect of Water Injection on Efficiency of Engine

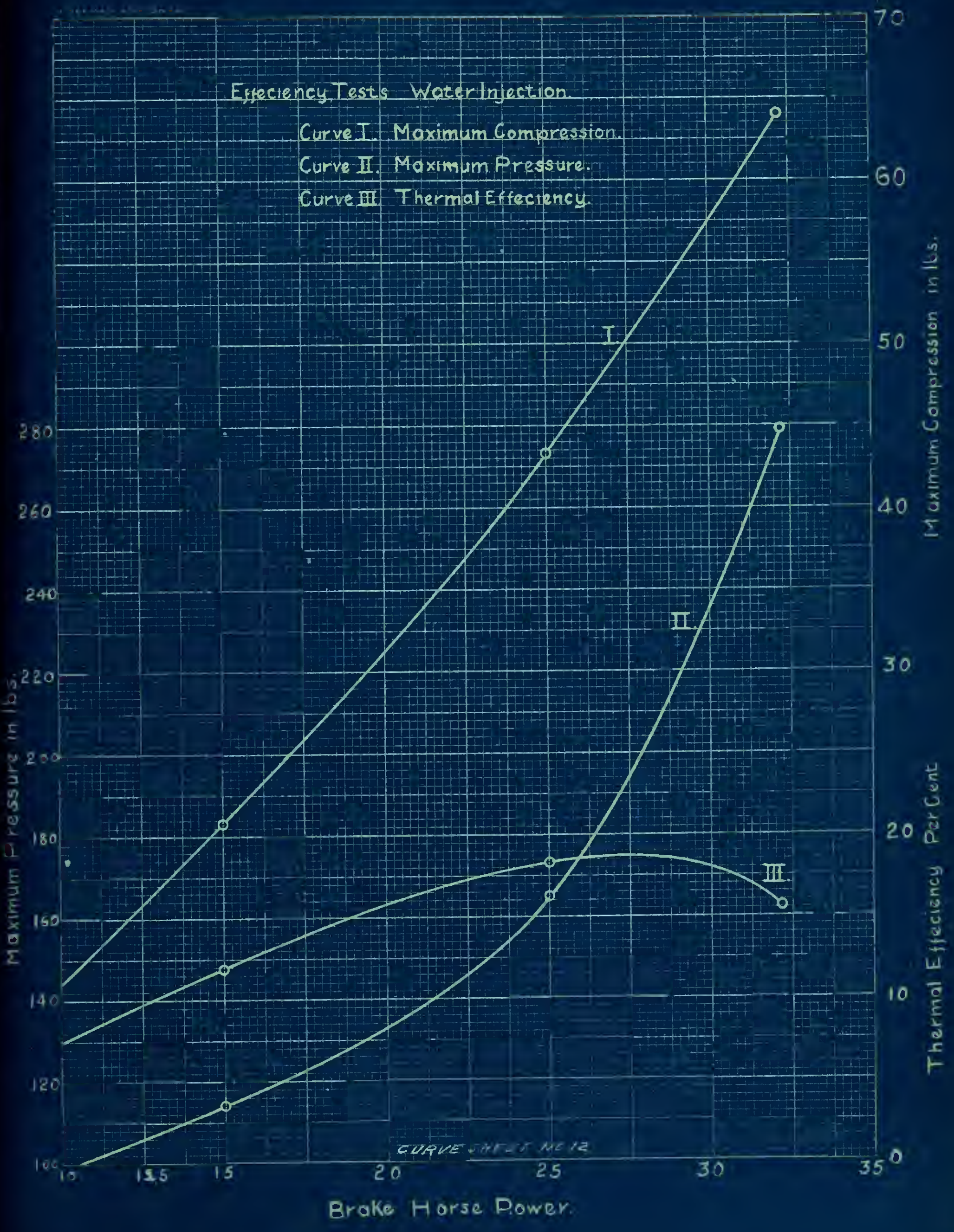
RUN NO.		Q
Duration of Test	hours	1
Revolutions per Minute		314
Net Brake Load	lbs.	109.5
Actual Brake Horse Power		34.4
DATA FROM CARDS		
a Maximum Pressure, lbs. per Sq. In.		279
b Compression Pressure, lbs. per Sq.In.		64
c Mean Effective Pressure,lbs.per Sq.In.Cyl. 1		104
" " " " " " " Cyl. 2		110
Indicated Horse Power		40.8
Frictional Horse Power		6.4
Mechanical Efficiency	%	84.3
Calorific Value of Gasoline per lb.		19,000
Gasoline per Hour		29.50
Gallons H. P. Hour		.1430
Jacket Water per Hour		1386
Inlet Cooling Water	Deg.F.	48.2
Outlet Cooling Water	Deg.F.	144.2
Range of Temperature	Deg.F.	96

TEST OF I. H. C. GASOLINE ENGINE
Armour Institute of Technology

RUN NO.		Q
Air in Room		70
Barometric Pressure	Ins. Hg.	29.5
B. T. U. per I. H. P. per Hour		13,710
B. T. U. per B. H. P. per Hour		16,300
Thermal Efficiency per I. H. P.	%	18.6
Thermal Efficiency per B. H. P.	%	15.63
Ideal Thermal Efficiency	%	43.8
Ratio of I. H. P. Efficiency to Ideal eff.	%	42.4
Ratio of B. H. P. Efficiency to Ideal eff.	%	35.6
HEAT BALANCE		
Heat Supplied	B.T.U.	561,500
Heat Supplied	%	100
Heat Equivalent of I. H. P.	B?T?U.	104,000
Heat Equivalent of I. H. P.	%	18.6
Heat Rejected in Jacket Water	B.T.U.	133,000
Heat Rejected in Jacket Water	%	23.7
Heat Lost in Exhaust, Radiatiob, etc.,	B.T.U.	324,500
Heat Lost in Exhaust, Radiation, etc.,	%	57.7
Temperature of Air in Intake Pipe	Deg.F.	95
Temperature of Gas in Intake Manifold	Deg.F.	65
Injected Water	pounds.	20.5
Ratio of Injected Water to Gasoline	%	69.5



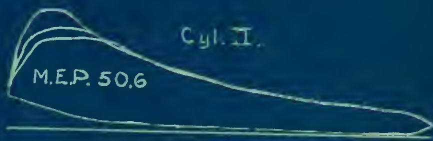
Effeciency Tests. Water Injection.
I.
II.
III.
Curve I. Mechanical Effeciency.
Curve II. B.T.U Per H.P. Hour.
Curve III. Gals Gasoline Per H.P. Hour.
Mechanical Effeciency.
Thousand B.T.U. Per H.P. Hour.
Gals Gasoline Per H.P. Hour.
Brake Horse Power.
CURVE SHEET NO 11
10
15
20
25
30
35
13
14
15
16
17
18
19
20
21
22
0
10
20
30
40
50
60
70
80
.12
.13
.14
.15
.16
.17
.18
.19



Effeciency Tests Water Injection.
Curve I. Maximum Compression.
Curve II. Maximum Pressure.
Curve III. Thermal Effeciency.
I.
II.
III.
Maximum Pressure in lbs.
Maximum Compression in lbs.
Thermal Effeciency Per Cent
Brake Horse Power.
CURVE SHEET No 12

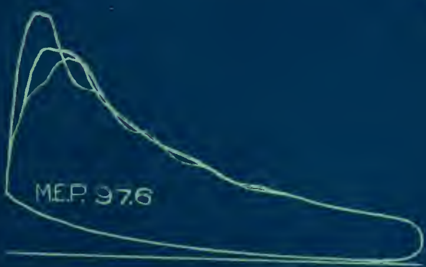
Sample Cards.
from.
I.H.C. Gasoline Engine.
Water Injection.

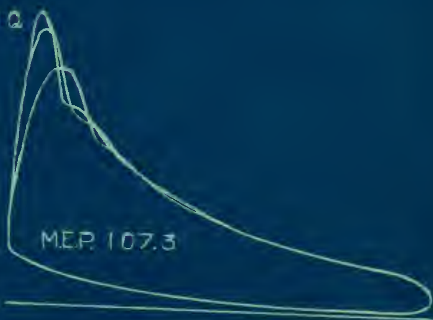
RUN R



RUN P

RUN Q





TEST OF I. H. C. GASOLINE ENGINE

GENERAL CONCLUSIONS

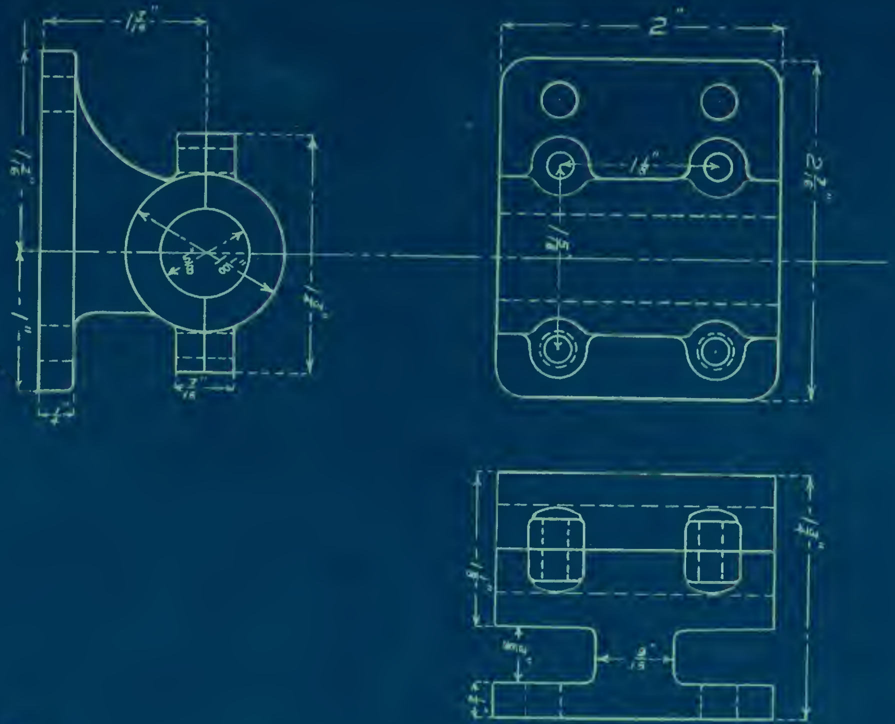
As a whole it seems that not much can be done to increase the efficiency of the engine, run as it is, under so many varying conditions. If it was going to be run at one load at all times this could be done. For instance we found at normal Horse Power that heating the inlet air increased the thermal efficiency, but in proportion it decreased the mechanical efficiency which means wear on the engine so it would only be feasable to heat the air if the engine were to be run on low loads. On the other hand, injecting water into the cylinders decreased the thermal efficiency, but also it eliminated the "knock" at as great as 40% over-load. Hence the mechanical efficiency was raised. From this we see if the engine is to be overloaded frequently and always run at least rated horse power, it is advisable to inject water even at the expense of a few per cent in thermal efficiency. Heating of the jacket water shows practically the same results as heating of

TEST OF I. H. C. GASOLINE ENGINE

the inlet air and the application of one or the other depends on its convenience. The most satisfactory way would be to have an injection fixed that could be turned on with overloads and a two way inlet air pipe which could be made to go around the exhaust manifold at low loads.

In conclusion we wish to say that as injecting water decreases the thermal efficiency and heating the air increases it, a combination of the two might work out very satisfactorily at all loads as the hot air vaporizes the gasoline before it enters the cylinder while the effect noted by injected water is produced in the cylinder. We would have liked to have made a series of runs under these conditions but limited time prevented.

For this reason we wish, following out this idea, experiments could be made at some future time to determine this and also the effect of using different fuels.



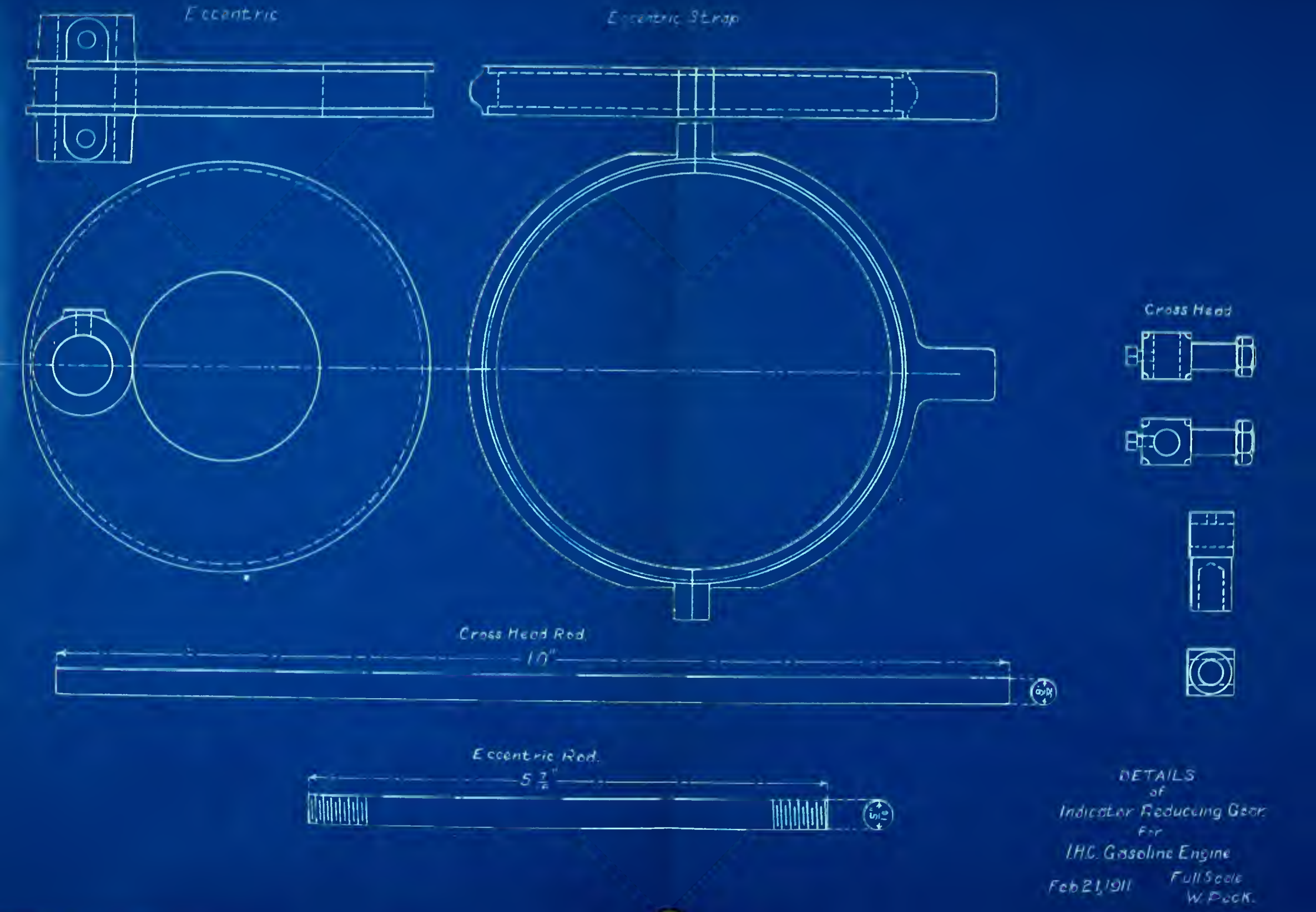
PILLOW BLOCK.
for
I.H.C. GAS ENGINE
Scale Full Size

W. Peck.

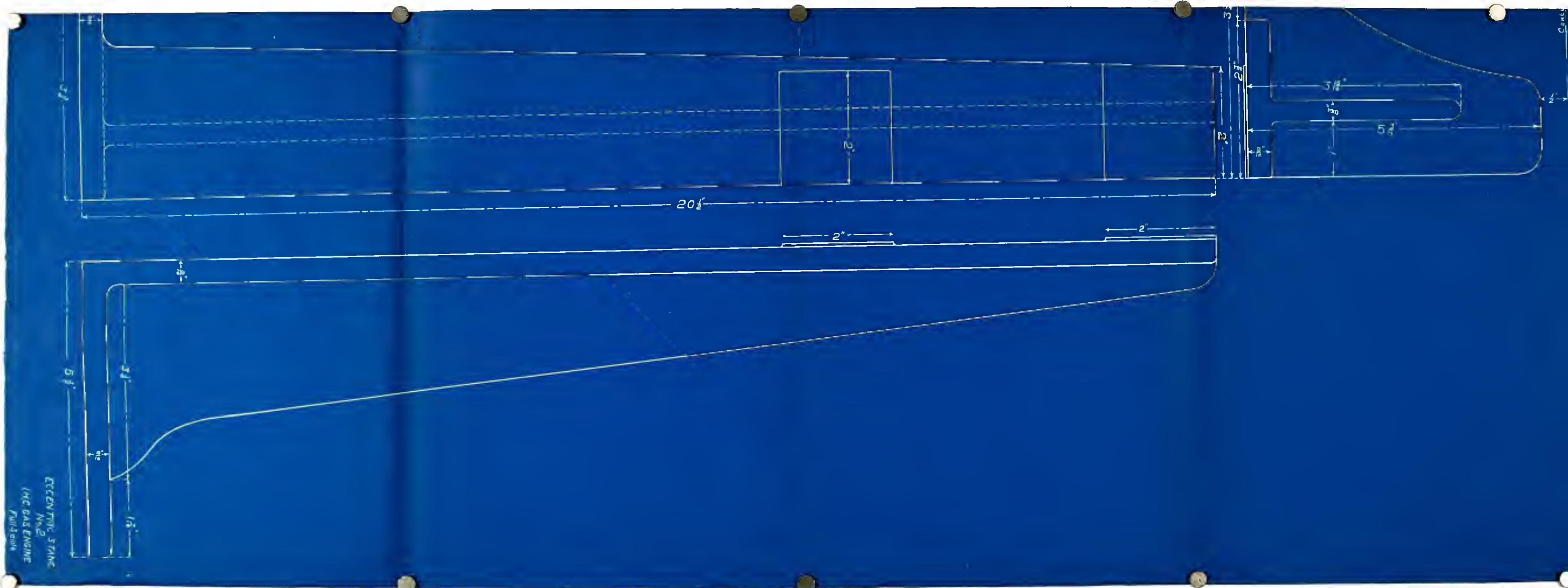
I.H.C. GAS ENGINE

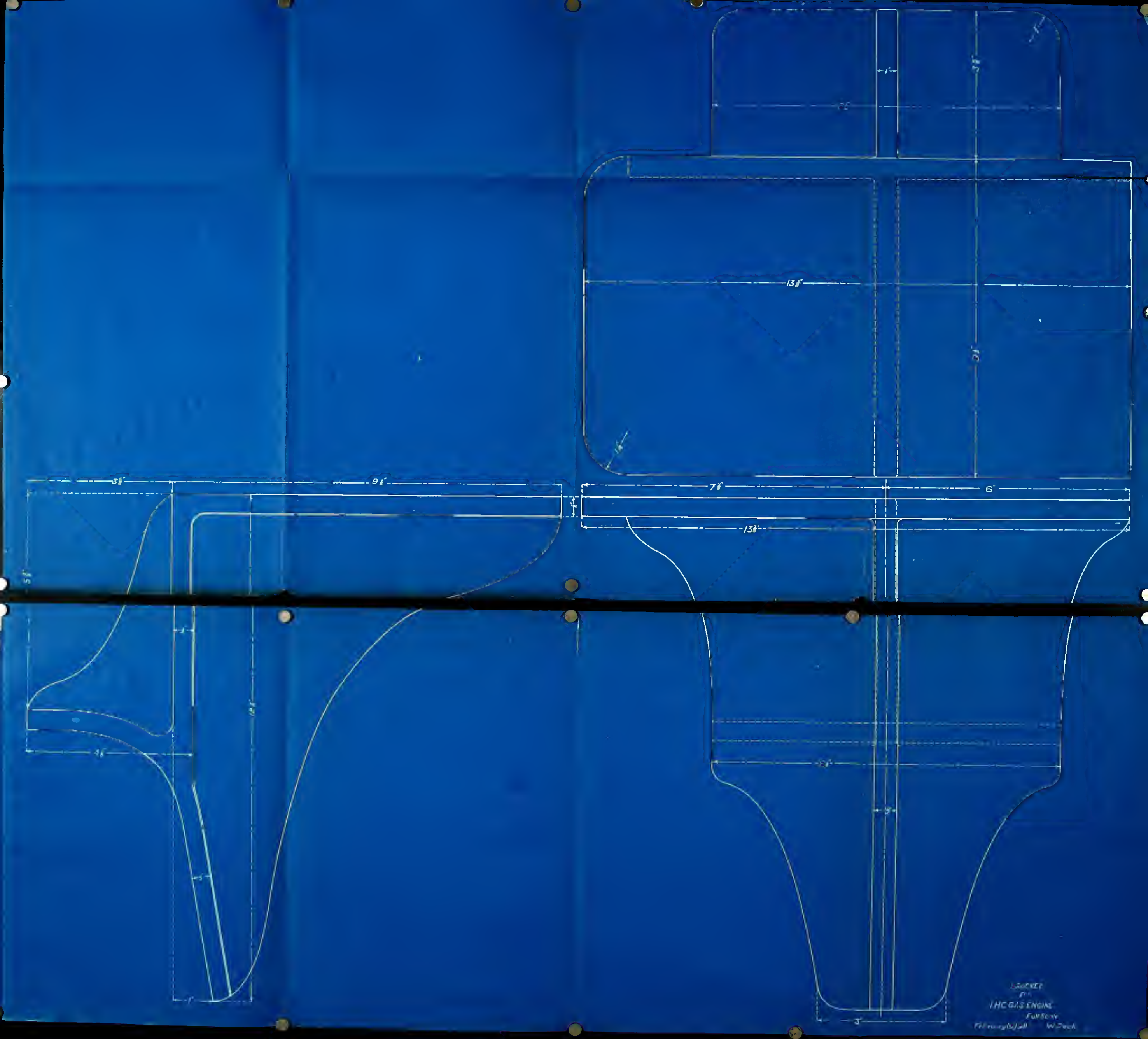
Full Scale.

W. Peck.

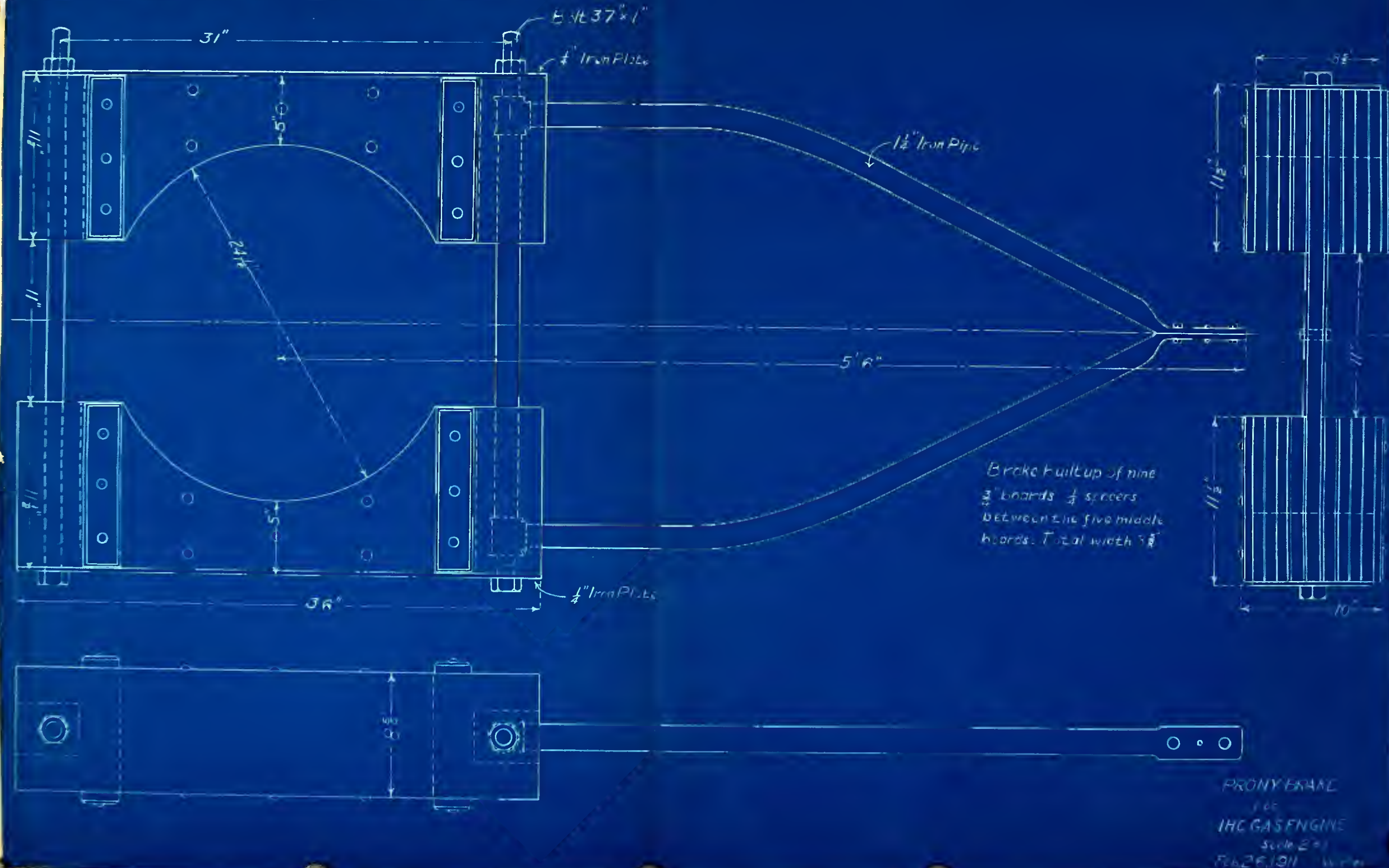

Eccentric
Eccentric Strap
Cross Head
Cross Head Rod
10"
Eccentric Rod.
5 7/16"
DETAILS
of
Indicator Reducing Gear
For
I.H.C. Gasoline Engine
Feb 21, 1911
Full Scale
W. Peck.

ECCENTRIC STAND
No.2
I.H.C. GAS ENGINE
Full Scale
Feb.22,1911. W.Peck.


20½
2"
2"
ECCENTRIC STAKE
No. 2
IHC GAS ENGINE
Full Scale



BRACKET
I H C GAS ENGINE
Full Scale
W. Peck


Bolt 37" × 1"
31"
¼" Iron Plate
5"
24½"
11"
1¼" Iron Pipe
5' 6"
36"
¼" Iron Plate
11½"
10"
Brake built up of nine ¾" boards ¼ spacers between the five middle boards. Total width 3⅝"
PRONY BRAKE
for
IHC GAS ENGINE
Scale 2 = 1
Feb. 26. 1911